

MODEL SAILING CRAFT



"ALBION" (OWNED IN 1929 BY G. HARVEY AND W. J. DANIELS, SERPENTINE M.Y.C., AND IN 1930 BY L. G. RUDD, Y.M. 6-M. O.A., SURBITON), WINNER INTERNATIONAL RACES 1929 AND 1930.

Frontispiece.

MODEL SAILING CRAFT

By
W. J. DANIELS
and
H. B. TUCKER

WITH A PREFACE BY THE LATE
C. N. FORGE
Hon. Secretary (1922-1935) and Chairman
(1936-1937) of the Model Yachting Association

SECOND EDITION
(REVISED)

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PREFACE

By the late C. N. FORGE,

Hon. Secretary (1922/1935) and Chairman (1936/7) of the Model Yachting Association.

DURING the last few years public interest in model yachting has increased marvellously, not only in Great Britain, but throughout the civilised world. Wherever there is a suitable sheet of water, model yacht clubs have been formed, and public authorities recognising the value of model yacht sailing and its importance as a healthy pastime, are gradually building more lakes for the purpose.

The old conception of model sailing as a childish pastime is practically dead, and the public to-day understands the difference between a model yacht and a toy boat. In fact, it may be said that model yachting has arrived and taken its place as one of the great international sports.

The reason of this is not far to seek when one considers the sport as it really is. In the first place, a model yacht has to be designed and built before it can be sailed. Whilst it is not everybody who is capable of designing and building his own boat, those who can do this gain a keener pleasure than those who merely buy their boats.

The design of a model yacht is in all respects analogous to that of a real yacht. It is a scientific business requiring study and calculation, and therefore this branch of the pastime has a high educational value.

The building of models again calls for a high degree of accuracy and craftsmanship. It is futile to design a boat carefully and not to build her true to design. Patience and accuracy are, therefore, essential.

In the designing and building one finds an ideal indoor hobby, and one that gives its

exponent the chance to express the natural creative instinct that lies in every man.

The actual sailing, on the other hand, provides a healthy outdoor pastime as a complement to the indoor hobby of designing and building them. Sailing is a sport that calls for keenness of observation, rapidity of decision, and, above all, good sportsmanship.

When one considers these points, the increasing popularity of model yachting is easily understandable. The surprising thing is not the recent boom in the sport, but that the advantages of the pastime have not been more widely appreciated.

* * * *

Possibly one thing that has delayed the progress of model yachting is the absence of a really first-class text-book. Several books have been published on the subject, some better than others, but there has been a crying need for just such a volume as the present handbook.

As Hon. Secretary of the Model Yachting Association, I have had every opportunity to see the work that has been done for the sport by the authors of "Model Sailing Craft."

Mr. W. J. Daniels is certainly one of the most celebrated model yachtsmen in the world. Apart from anything else, six of the eight International Races that have been held since the war have been won by models of his design and building, and on five of the occasions he has actually skippered the winning boat.*

* Since this Preface was written, Mr. W. J. Daniels has won two more international events in Britain and one at Hamburg.

PREFACE

Mr. Daniels' achievements are the result of a lifelong study. In his early days he met with scant success, but eventually patience and hard work brought its own reward, and to-day his name is known in every part of the world where there are model yachts.

His collaborator, Mr. H. B. Tucker, has sailed real yachts all his life. Immediately after he was demobilised from the R.N.V.R., he started model yachting with a view to experimenting. He soon made a name in the executive organisation which controls the sport in this country. He served from 1925-1930 as Chairman of the Model Yachting Association, and had a large share in drafting the present

sailing and rating rules. He founded the International Model Yacht Racing Association, of which he has been the Hon. Secretary since its inception.* He has also done an immense amount of journalistic work in connection with the sport, and acted as Editor of *The Model Yachtsman* since its foundation.†

The combination of these two authorities has produced a book that cannot fail to be of the greatest use and interest to every model yachtsman.

* The international association is now known as the International Model Yacht Racing Union, of which Mr. Wm. M. Carpenter is the Hon. Secretary.

† Now incorporated in *Marine Models* of which Mr. H. B. Tucker is still Editor.

AUTHORS' PREFACE TO SECOND EDITION

IN presenting the Second Edition of "Model Sailing Craft," the Authors wish to express their thanks for the favourable reception accorded the First Edition on its publication. As, however, some years have since elapsed, the present Edition has been entirely revised and brought up to date.

In the Second Edition the history of model yachting is not dealt with at such length, but the chapters on designing, building and sailing have been almost entirely re-written in some cases, and much fresh matter included. New designs to all recognised classes including the International "M" (Marblehead) have also

been incorporated, and whether they are used as examples by students of design, or for actual building purposes, it is hoped that they will prove useful to readers.

It is considered that these alterations will increase the value of "Model Sailing Craft" as a text-book. Nevertheless, by the elimination of all superfluous matter, it has been found possible to produce the Second Edition at a somewhat cheaper price without in any way impairing the utility of the work.

W. J. DANIELS.
H. B. TUCKER.

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MODEL SAILING CRAFT

INTRODUCTION

THE origin of the sailing boat is wrapped in the mists of antiquity, but probably the first idea of sailing came when pre-historic man spread his skin cloak to the breeze and found that his log canoe blew along without labour at a more rapid rate than he could propel it with his crude paddle.

Since the first dawn of early civilisation, model-making has possessed a fascination for mankind, but when and where the first model sailing craft was fashioned we have no means of knowing. Certain it is, however, that models have been found in the ancient Egyptian tombs, and since these were of the craft in which the Egyptian went a-pleasuring on the Nile, we may safely style them model yachts.

From the ancient Egyptians to the Middle Ages is a long step, but then we find that there was much model making. These early European models are mainly found in the Mediterranean countries, and frequently take the form of Church Ships. The sailor of those days, when starting out on a perilous voyage, or in moments of dire danger, would often vow to give a ship to the Virgin or to his patron saint, if he was spared to return safely. Consequently the Church Ships were usually the work of sailors, not craftsmen, and they are often crude and inaccurate in proportions and details. We must also remember that they were made to be hung up before the Altar, and consequently viewed from below, which would naturally affect the perspective. Although these Church Ships cannot, therefore, be regarded as historically exact, their study is of great interest.

From the collector's point of view, the best periods are the seventeenth and eighteenth centuries, when many magnificent models were turned out by shipwrights and designers. Fine examples of these can be seen in the Greenwich Museum, South Kensington Museum, the Louvre, the Dutch Museums, etc.

During the Napoleonic wars, the French prisoners of war also made many beautiful model ships. These were made of bones from the mutton on which the prisoners were fed, and by selling them the prisoners made a small revenue with which to buy little luxuries. In those days £5 or £10 was a good price to give for one of these little ships, which took months of patient work to execute. To-day good examples (after proper restoration of the rigging), fetch tremendous prices, as much as £1500 having been paid for a particularly fine specimen. The detail work in these little vessels is often most beautifully executed. The bone is laid on a wooden block, and in some of the smaller examples the rigging is done with human hair. Bone ships are amongst the most interesting and beautiful models extant, and are usually extremely accurate.

About 1840 steam began to take the place of sail in the Navy, and from that time naval models lose their interest for the student of sail; but in merchantmen the golden age of sail was then just commencing, as 1840 onwards was the age of the clipper ships.

For about thirty-five years sail held its own on the longer trade routes, but gradually steam began to be used, especially for mails and fast cargo services. Sailing vessels were then relegated to less important routes, and services where low freights were more important than fast passages. Under these conditions many of the clippers had their sail spreads cut down and crews reduced. Big cargo-carrying capacity was at that time of more importance than speed, and the big iron ships then had their day. Little by little, steam ousted these also, and to-day hardly a single sailing ship spreads her lofty pyramids of canvas to the wind. There are still a good many models of these ships to be found in out-of-the-way places. Many of these were made by sailormen

MODEL SAILING CRAFT

to pass away the time on long, tedious voyages. Others are the work of builders and shipwrights. The latter are usually better than the sailor-made models, as the hull lines are more accurate.

Even in our fishing fleets, steam and the ubiquitous motor are rapidly supplanting sail, and soon the yachting fleets will be the only representatives of sail afloat. But here again the motor is gaining ground, so that the time may soon come when, except for racers, sailing yachts are a rare sight. It is, therefore, a worthy task for the model maker to preserve the memory and detail of the vessels which made glorious history in the past.

It is not within the scope of the present volume to give a detailed history of sailing craft or early models, and the student is referred to the many excellent books which have been written on the subject. The foregoing brief survey, however, serves to show that model-making is a very ancient art, and the modeller of to-day, whether he makes his models as "show" pieces or as actual miniature sailing vessels, is but one of a long line of craftsmen that stretches back to the days of the Pharaohs, and even before.

* * * *

Model sailing craft can be divided into two main categories—"show" models and sailing models.

Show models can be of several types. There is the waterline model, which shows the ship as she appeared above water, complete with spars and rigging. These are very decorative if well executed.

Another type is the hull model. This often takes the form of a half-model. The latter are frequently made by ship and yacht builders to show the hulls as actually designed.

The third form is the complete model, and this is the most interesting of all to the student of naval architecture.

Any sort of sailing vessel, from a lordly full-rigged ship to a sailing dinghy, may be built as a show model. Whatever the subject chosen to reproduce, the greatest accuracy should be employed even to the smallest

details. The aim of this kind of model is to be a record.

There is another class of show model which is usually styled a "decorative" model. These are nearly akin to the Church Ships of early days. Decorators to-day often use a ship model as an ornament. The position in which these are to be set precludes close examination, and intricate detail would be wasted. Broad effect is what is aimed at. These ships are often of the type styled "conventional." Decorative ships are often used by silversmiths and very fine work is often to be seen in this connection.

Several good treatises have been written on the making of show models, and the main subject of the present book is the actual sailing model.

Actual sailing models can also be divided into two categories. These are the racing model and the style of model which is frequently styled the "prototype" model. The latter term would really apply with equal force to the racing models, but is used to imply models of non-racing craft. In this category fall model ships and square riggers—schooners, ketches and the like—barges, fishing craft and many others. It will be impossible in the present volume to deal with all these different types, but the main ones will be touched upon with more or less detail. The larger part of our subject is the racing model yacht, but methods of construction and rigging (with minor alterations) apply to most other craft as well.

A good deal of attention has been devoted to the subject of actual sailing. Model yacht sailing is one of the most healthy and fascinating pastimes. Little by little, as one's skill grows, one finds that the little craft is responsive, tractable and that except for the fact that perforce her skipper is not aboard, she can be handled like a real yacht and perform almost the same evolutions in the same manner.

It is a great pleasure to watch the work of one's brain and hand threshing to windward in a gale or under the thousand and one different combinations of wind and sea that nature bestows on us. Many model sailors

INTRODUCTION

find much pleasure in sailing alone, whilst to others the keen excitement of racing appeals. And, after all, racing against boats of a similar type and size is the supreme test of design and workmanship. Every boat appears to be performing well when she is sailing alone, and it is only when she is pitted against a rival that her real merits can be properly judged.

* * * *

It has been the aim of the authors in

compiling the present treatise to explain every process in the designing, building and sailing of model yachts in the clearest possible manner without leaving anything to the imagination. Everything has been detailed step by step, and all technical terms explained as they occur. If this book helps to smooth the way of the recruit and assist him to enjoy the fascinating and instructive sport of model yachting, it will have served its purpose.

The Authors of this book have to acknowledge with thanks the permission of the proprietors of *MARINE MODELS*, 52, Fetter Lane, London, E.C.4, to reproduce many of the illustrations and diagrams used in these pages. Thanks are also due to the Model Yachting Association for permission to include various Rating Rules, and to those model yachtsmen, who by their help and encouragement, have assisted in the preparation of this work.

CHAPTER I

Yacht Racing and Model Yacht Racing—Why Rating Rules are Necessary—The 10-Rater Rule—The 6-Metres and 12-Metres I.Y.R.U. Classes.

THE sport of model yacht racing has much in common with yacht racing, even as the models themselves are akin to their bigger sisters. The differences between the miniature and the full-size are attributable to one thing only, that the model has no skipper aboard, whilst the yacht has.

In many ways the term "miniature yacht" is a better description than "model yacht," as the little ships are veritable miniature yachts. Moreover, the term "model yacht" is applied indiscriminately to the toy boats which are sold in the shops, which even when they are sufficiently well-made to sail at all, are at most capable of reaching with the wind abeam, whilst the real model yacht is able to perform creditably on every point of sailing.

In model racing, as in yacht racing, the best sport is that between boats of the same class and type. In order to secure this it is necessary to have a system of measurement. These systems of measurement are known as "Rating Rules," and, naturally, in these the model has closely followed the prototype. In order to understand the origin of these Rating Rules, it is necessary to look into the history of real yacht racing.

The history of real yacht racing in this country dates back to the reign of King Charles II., and the earliest recorded race was one from the Pool to Tilbury and back between the yachts of the King and the Duke of York.

Owing to various causes very little progress was made for many years until the Royal Yacht Squadron came into being.

In the early days of the "Squadron" there was no attempt to classify boats or handicap them, and consequently the largest yacht in the race almost invariably won. This was dull work for all but the owners of the big boats, and in 1843 a scale of time allowances was adopted based on the tonnage of competitors and the length of the course.

The origin of the term "tonnage" (or "tunnage") is rather curious, as it appears to have been derived from the number of tuns (casks) of wine a vessel's hold would contain. Thus a ship of 100 tons should have been able to carry a cargo of 100 tuns of wine.

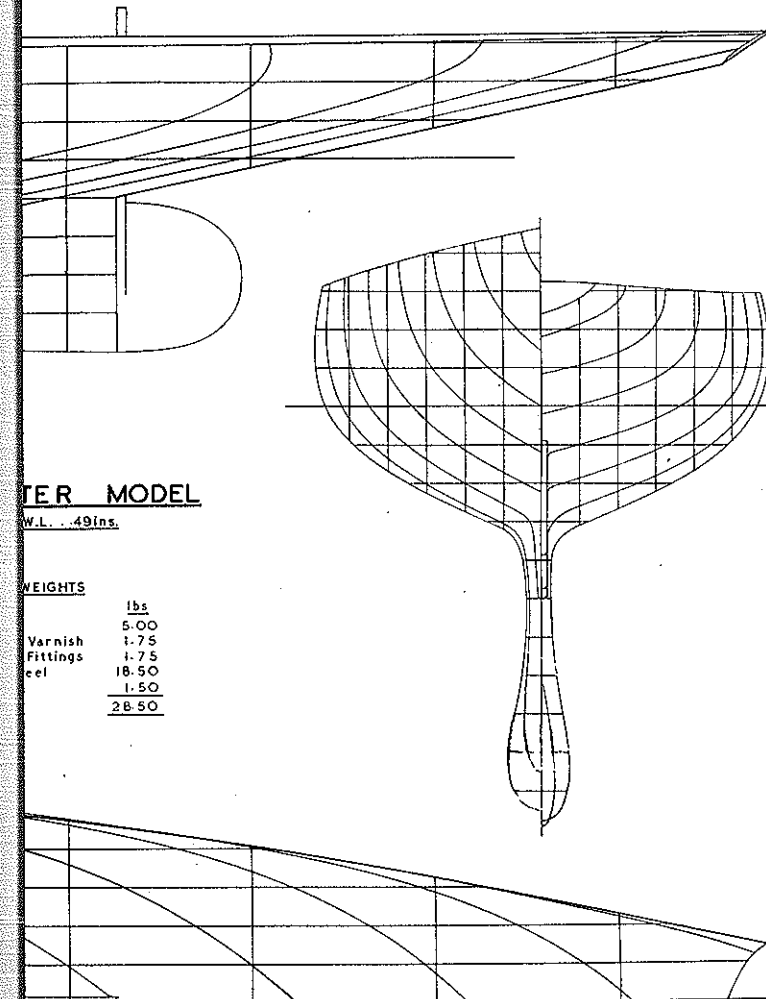
* * * *

Although model yacht racing has not as long a history as yacht racing, some of our oldest clubs can trace their origins back for fifty, sixty and even seventy years. As with yachts, model yachtsmen found the necessity of Rating Rules, and these were mostly based on the rules prevalent for full-sized craft.

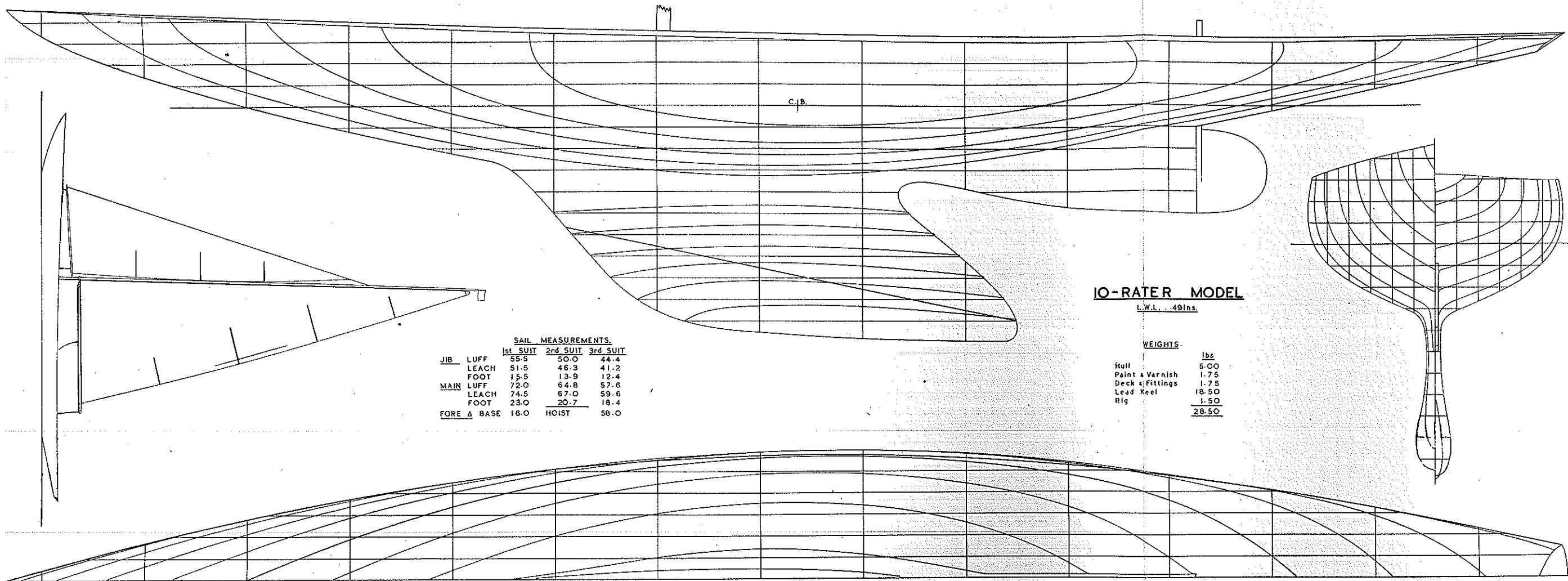
The oldest class of models still in use is the 10-Rater to the Length and Sail Area Rule. This rule was invented by Dixon Kemp and adopted for yachts in 1887. It was a great improvement on all previous systems of measurement and embodied two entirely new features. Hitherto the length taken for measurement had been length over all, but in this formula load water line was used, and sail which had formerly been untaxed, was now measured.

Before discussing this formula, it might be as well to deal generally with the factors which govern the speed of a yacht. In boxing a good big 'un will always beat a good little 'un, and exactly the same applies to yachts. Of course, in boxing men are classified by weights, but the problem of classifying yachts is by no means so simple. It is possible to more or less even things up by judicious handicapping, but the best sport will always be between vessels of equal class sailing on equal terms.

The three main factors that govern the speed of a yacht are her length, displacement and sail area. Of these length is the most important and in this connection it is not the load water line length nor yet the length over all which counts, but the actual length used when sailing.



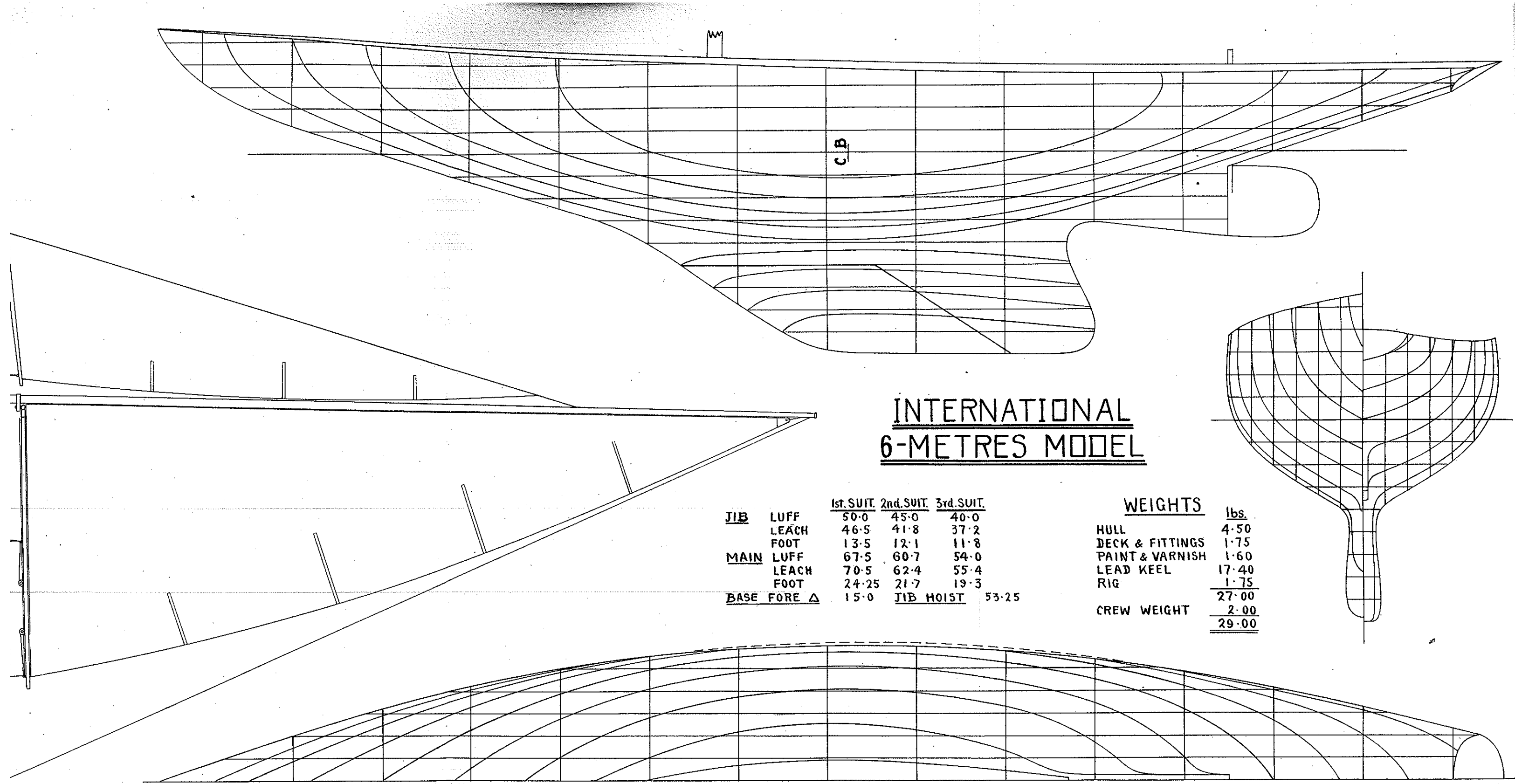
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SCALE: ONE-FIFTH OF FULL-SIZE.

Folding Plate I.]

[To face page 4.



INTERNATIONAL 6-METRES MODEL

		1st. SUIT.	2nd. SUIT.	3rd. SUIT.
JIB	LUFF	50.0	45.0	40.0
	LEACH	46.5	41.8	37.2
	FOOT	13.5	12.1	11.8
MAIN	LUFF	67.5	60.7	54.0
	LEACH	70.5	62.4	55.4
	FOOT	24.25	21.7	19.3
BASE FORE Δ		15.0	JIB HOIST	53.25

WEIGHTS

	lbs.
HULL	4.50
DECK & FITTINGS	1.75
PAINT & VARNISH	1.60
LEAD KEEL	17.40
RIG	1.75
	<u>27.00</u>
CREW WEIGHT	2.00
	<u>29.00</u>

SCALE: ONE-QUARTER OF FULL-SIZE.

[To face page 5.]

NATIONAL RES MODEL

WEIGHTS

	lbs.
HULL	4.50
DECK & FITTINGS	1.75
PAINT & VARNISH	1.60
LEAD KEEL	17.40
RIG	1.75
	27.00
CREW WEIGHT	2.00
	29.00

53.25

[To face page 5.]

THE 10-RATER RULE

A further consideration which must govern the making of Rating Rules is that a designer will naturally design a boat that takes full advantage of the rule, and any untaxed or lightly taxed dimension will lead to excess in that direction. For instance, when boats were rated by length over all (L.O.A.) only, the designer naturally produced the biggest possible boat on the given measurement. The result was a stumpy, horrible craft with no overhangs, immense beam, great draught, and an enormous sail spread.

The Length and Sail Area rule is :—

$$\frac{\text{L.W.L.} \times \text{S.A.}}{6000} = \text{Rating.}$$

It will be seen that this rule takes into account two of the main speed factors. As, however, the length taken for the rating is L.W.L., the natural consequence was that boats were designed with overhangs to gain additional unmeasured sailing length, and the type developed soon became a beamy saucer of the typical scow type with long overhangs.

Numerous classes were built under the rule, but the only class surviving to-day is the 10-rater model class. These boats proved admirable models, and, though the class is about fifty years old, the 10-rater is to-day going stronger than ever, and is by far the most numerous and popular class of model in England. In fact about a thousand 10-raters are on the Model Yachting Association's Register.

THE 10-RATER CLASS

For the sake of reference the rule is given below :—

$$\frac{\text{L.W.L. (in inches)} \times \text{S.A. (in square inches)}}{6000} = 10$$

The class has been brought up to date as regards sail area measurement, which is now taken in accordance with the latest I.Y.R.U. regulations (as given later in this chapter). Only 85 per cent. of the area of the fore triangle is taken in the computation of total sail area for rating. Batten limits in this class are optional. When they are adopted the number of battens is limited to four, equally spaced. The length

of the upper and lower battens must not exceed 5 in., and the intermediate battens 7 in. If batten limits are not adopted, the total area of the sail is taken in calculation of rating. When a triangular mainsail is adopted, the headstick is limited to a length of 1 in. Models in this class are measured in fresh water. They are not obliged to carry the same sized spars on small suits of sails as they do on the biggest suit.

The modern 10-rater is, however, a very different craft from that of even twenty years ago. Early 10-raters measured 36-38 in. on the L.W.L., with an overall length of about 60 in., and a displacement of 16-20 lb., whereas a modern boat of the same class is 48-50 in. L.W.L., 66-72 in. overall, and displaces anything up to about 30 lb. This increase in size is brought about partly by the different methods of sail measurement now used, and partly by the superiority of modern sailplans which give greater driving power per square inch of canvas. The design included in this book can be regarded as a typical example of an up-to-date 10-rater.

The Length and Sail Area Rule was followed by the two Linear Rating Rules, the I.Y.R.U. (International Yacht Racing Union) Rules of 1908 and 1920, and finally in 1933 the present I.Y.R.U. Rule was promulgated. It was adopted for model use in the following year, and two classes are now in use.

THE 6-METRES AND 12-METRES I.Y.R.U. CLASSES

The classes of I.Y.R.U. models which are used in Britain are the 12-m. (scale 1 in. = 1 ft.) and the 6-m. (scale 1½ in. = 1 ft.)* It is claimed that these models are exact scale models of existing racing classes, and consequently the rules as applied to models are so adapted that the models sail as nearly as is possible under the same conditions as the prototypes. They are measured under exactly the same rule as their larger sisters, with all the limits exactly

* RATINGS OF MODELS IN INCHES—		
	Salt Water.	Fresh Water.
12-m. —	39.37 in.	39.57 in.
6-m. —	32.80 in.	32.96 in.

MODEL SAILING CRAFT

to scale. Scantling rules are, of course, out of the question, but the little craft are measured without crew, as their larger sisters are. After measurement a weight equivalent to the approximate scale weight of the real yacht's crew is put aboard the model and carried in the approximate position where the real yacht's crew would be in her cockpit. The rule under which the 10-rater is built is fifty years old, and the full-size classes to it long since defunct. Of other model classes now in use, the M-class (Marblehead), and 36-in. Restricted Classes, are to rules formulated specially for models. The rule under which the A-class is built is so far a rule that has only been applied

L.O.A.		58 to 62 in.
L.W.L.		38 to 40 "
Beam		11 to 12 "
Draught		8½ to 9 "
Displacement		22½ to 27 lb. (excluding the 2 lb. added as crew weight).

The 12-m. class is still fairly popular in Scotland, but has no following in England, where the A-class has entirely eclipsed it. Actually, the 12-m. is a little too light in draught and displacement for the size, and is not quite such a satisfactory boat as the A-class. The reason of this is that the model is on too small a scale in comparison with the

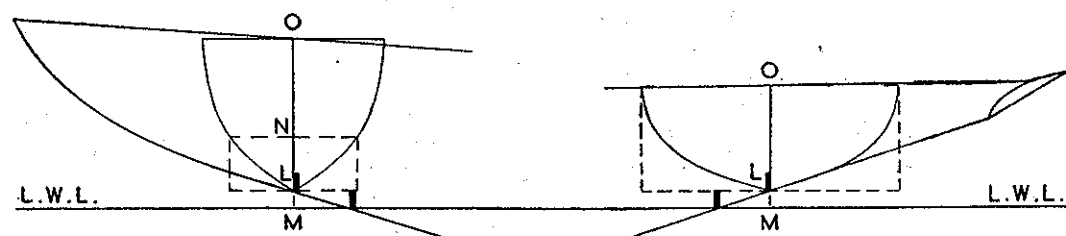


FIG. 1.—METHOD OF MEASURING BOW AND STERN TAX.

Bow Tax.

M.L. = 1.5 per cent. of Class Rating.
L.N. = 5 per cent. of Class Rating.
= Height for Measurement.
M.O. = Height for Freeboard Measurement.

Stern Tax.

M.L. = 1.5 per cent. of Class Rating.
L.O. = Height for Measurement.
M.O. = Height for Freeboard Measurement.

to models though it is eminently suitable for full-sized yachts, and in the eyes of some, superior to any rule that has yet been used for the prototype. The I.Y.R.U. models can, therefore, justly claim to be the only miniature yachts that are really models of present-day racing craft.

The 6-m. is a very nice handy little class of boat, and can be recommended to those whose physique does not permit them to sail the A-class. Though comparatively a newcomer, the class has taken on extremely well in Scotland, and is now adopted by a number of English Clubs also. It has also been recognised by the International Model Yacht Racing Union as one of the classes for international racing. The average size of one of these boats is:—

prototype, and the restrictions on draught and displacement, though eminently suitable to the prototype, bear over-hardly on such a small scale model. In consequence, a successful 12-m. model would vary greatly in the relative hull and sail dimensions from what would succeed in a full-sized yacht. The 12-m. models are somewhat smaller than the A-class, but considerably lighter in displacement.

The I.Y.R.U. Rule as applied to models is as follows:—

I.Y.R.U. RATING RULES

As applied to Model Yachts, containing all alterations up to December, 1938.

$$\frac{L + 2d + \sqrt{S} - F}{2.37} = \text{Rating}$$

THE I.Y.R.U. RATING RULE

Where L = Length measured at a height of 1.5 per cent. of the Class Rating above the L.W.L.,* plus 1½ times the difference between the girth at the bow ending of this length measured to points, 5 per cent. of the Rating above L† and twice the vertical height from L to these points, plus ½ of the difference between the girth, covering board to covering board, at the stern ending of this length and twice the vertical height of the side of the yacht at this station. The minimum difference of

measured on the two sides of the yacht from the covering board to corresponding points on the hull surface at a level 12.5 per cent. of the Class Rating below the L.W.L.‡ (See Fig. 2.)

Where S = Sail Area. Note.—Only 85 per cent of area of fore-triangle is used in computation of total area.

Where F = Freeboard taken at the Girth station, plus the freeboard at the bow L ending, plus the freeboard at the stern L ending; the sum to be divided by 3. The maximum freeboard to be used as a minus quantity in the formula when calculating the Rating shall be as per scale at foot.||

Restrictions

Hollows in the Surface of the Hull.—No hollow shall be allowed in the surface of the hull between the L.W.L. and the sheer line, excepting in the profile of the stern forward of the point of measurement of L. Hollows in the surface of the hull at the stern immediately resulting from the hollow allowed in the stern profile are not prohibited by this clause.

Draught.—The maximum draught allowed shall be in accordance with the Tables given later in this chapter. If the draught exceeds that allowed, three times the excess shall be added to Rating.

Sheer.—The sheer of the yacht is to be a fair continuous concave curve.

Tumble Home.—The tumble home on each side is not to exceed 2 per cent. of the extreme beam. When the tumble home exceeds the amount allowed, three times the excess shall be added to the Rating.

Displacement.—Displacement shall not be less than the amount given in the Tables later in the chapter. If a yacht is less than the displacement required by the rule for her length on L.W.L., then the difference between the length on L.W.L. to which her displacement actually corresponds, and the actual

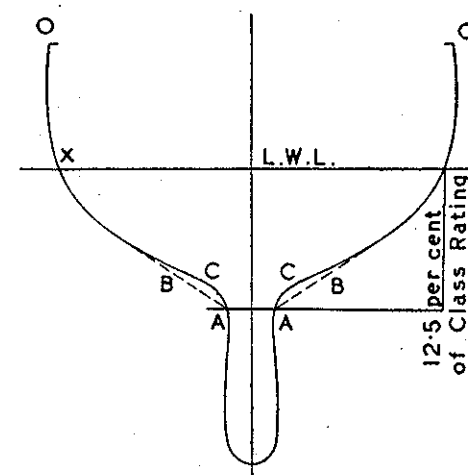


FIG. 2.—METHOD OF TAKING d MEASUREMENT.

Taken on Both Sides of Yacht.

OCA - OBA = d.
XO = Freeboard Measurement.

girth at the bow station, as defined above, is to be 30 per cent. of twice the said vertical height.† (See Fig. 1.)

Where d = The Girth Difference. This is measured at 0.55 L.W.L. from its forward ending, and is the sum of the differences between the skin girth and the chain girth

* Height for L Measurement above L.W.L.
12-m.—0.59 in. taken as 0.6 in.
6-m.—0.49 in. taken as 0.5 in.

† 5 per cent. of Rating above L.
12-m.—taken as 1.9 in.
6-m.—taken as 1.62 in.

‡ 30 per cent. of Twice Vertical Height.
12-m.—1.14 in.
6-m.—0.98 in.

§ Depth for d Measurement below L.W.L.
12-m.—4.92 in. taken as 4.9 in.
6-m.—4.1 in.

|| Freeboard, Maximum, to be used as Deduction.
12-m.—3.95 in.
6-m.—4.0 in.

MODEL SAILING CRAFT

length on L.W.L. will be doubled and added to the length measurement.

Limitation on Minimum Beam.—The minimum beam measured at $\frac{1}{2}$ of the measured midship freeboard above L.W.L. at the point of greatest beam on that line shall be as per scale at foot.* Any deficiency to be multiplied by 4 and added to L measurement. This rule does

* Minimum Greatest Beam Allowed.
12-m.—11.8 in.
6-m.—10.0 in.

not apply to yachts built or building before September, 1937.

Maximum Height of Sailplan.—The maximum height allowed, measured from the deck along the mast, shall be as per Table at foot.†

Maximum Height of Fore-Triangle.—The maximum height allowed, measured from the

† Maximum Height of Sailplan.
12-m.—82.0 in.
6-m.—71.1 in.

TABLE OF MINIMUM DISPLACEMENTS AND MAXIMUM DRAUGHTS

6 METRES (1 $\frac{1}{2}$ in. = 1 ft. 0 in.).

L.W.L. in.	Min. Disp. lb.	Max. Dght. in.	L.W.L. in.	Min. Disp. lb.	Max. Dght. in.	L.W.L. in.	Min. Disp. lb.	Max. Dght. in.	L.W.L. in.	Min. Disp. lb.	Max. Dght. in.
35.0	17.78	8.33	37.0	20.65	8.65	39.0	23.81	8.97	41.0	27.28	9.29
35.2	18.05	8.37	37.2	20.95	8.69	39.2	24.14	9.01	41.2	27.64	9.32
35.4	18.33	8.40	37.4	21.25	8.72	39.4	24.47	9.04	41.4	28.00	9.35
35.6	18.61	8.43	37.6	21.56	8.75	39.6	24.81	9.07	41.6	28.37	9.39
35.8	18.89	8.46	37.8	21.87	8.78	39.8	25.15	9.10	41.8	28.75	9.42
36.0	19.18	8.49	38.0	22.19	8.81	40.0	25.50	9.13	42.0	29.13	9.45
36.2	19.47	8.53	38.2	22.51	8.85	40.2	25.85	9.16	42.2	29.50	8.48
36.4	19.76	8.56	38.4	22.83	8.88	40.4	26.20	9.19	42.4	29.89	9.51
36.6	20.05	8.59	38.6	23.15	8.91	40.6	26.56	9.23	42.6	30.28	9.55
36.8	20.35	8.62	38.8	23.48	8.94	40.8	26.91	9.26	42.8	30.67	9.58

12 METRES (1 in. = 1 ft. 0 in.).

L.W.L. in.	Min. Disp. lb.	Max. Dght. in.	L.W.L. in.	Min. Disp. lb.	Max. Dght. in.	L.W.L. in.	Min. Disp. lb.	Max. Dght. in.	L.W.L. in.	Min. Disp. lb.	Max. Dght. in.
42.0	26.12	8.36	44.0	29.79	8.68	46.0	33.80	9.00	48.0	38.16	9.32
42.2	26.47	8.39	44.2	30.18	8.71	46.2	34.22	9.04	48.2	38.62	9.35
42.4	26.82	8.43	44.4	30.57	8.74	46.4	34.65	9.07	48.4	39.07	9.38
42.6	27.18	8.46	44.6	30.96	8.77	46.6	35.07	9.10	48.6	39.53	9.42
42.8	27.54	8.49	44.8	31.36	8.81	46.8	35.50	9.13	48.8	40.00	9.45
43.0	27.91	8.52	45.0	31.76	8.84	47.0	35.94	9.16	49.0	40.47	9.48
43.2	28.28	8.55	45.2	32.16	8.87	47.2	36.37	9.19	49.2	40.94	9.51
43.4	28.65	8.59	45.4	32.56	8.90	47.4	36.82	9.22	49.4	41.42	9.54
43.6	29.03	8.62	45.6	32.97	8.94	47.6	37.26	9.26	49.6	41.90	9.58
43.8	29.41	8.65	45.8	33.38	8.97	47.8	37.71	9.29	49.8	42.39	9.61

THE I.Y.R.U. RATING RULE

deck along the mast, shall be as per Table at foot.*

Battens in Mainsails.—The number shall not be more than four and shall divide the after leach into four approximately equal parts. The length of intermediate battens shall be as per Table at foot, upper and lower battens being one-fourth shorter.†

Limit to Size of Spinnakers.—The maximum dimensions of a spinnaker shall not exceed the following:—

Maximum length of luff and leach (which shall be of equal length, 80 per cent. of the square root of (I squared plus J squared) plus the scale of 2.5 metres.‡

N.B.—I is the height of fore-triangle; J is the base of fore-triangle.

Sleeves or tubular pockets extending from Spinnakers are prohibited.

Limit of Size of Balloon Jibs.—In yachts of 6 metres the clew of the biggest jib shall not extend, when new, more than 0.4 Rating, and in yachts of 6 metres more than 0.5 Rating, abaft the fore side of the mast measured head to wind. No jib shall have a club or other device for extending it to other than a triangular shape.

Headsticks.—Any dimension of headsticks to triangular mainsails shall not exceed $2\frac{1}{2}$ per cent. of Rating.§

Masts (Wood or Metal).—Permanently bent masts, rotating masts, double luffed sails, and similar contrivances are prohibited.

Booms.—A boom must not be permanently concave in a fore-and-aft direction. Permanently or mechanically bent booms, and struts and outriggers on booms, are prohibited.

* Maximum Height of Fore-Triangle.
12-m.—61.5 in.
6-m.—53.3 in.

† Batten Limits.
12-m.—5.9 in. and 4.4 in.
6-m.—6.6 in. and 5.0 in.

‡ Scale of 2.5 Metres.
12-m.—8.2 in.
6-m.—13.67 in.

§ Headstick Limits.
12-m.—1.0 in.
6-m.—0.8 in.

A jackstay or rail, if used, must be fixed in the fore-and-aft line of the boom.

The maximum height allowed from the deck to the top of the black band marking top of lowest position of boom for measurement of sail area is as Table at foot.||

CREW WEIGHT

The carrying of crew weight in these Classes is entirely optional. If carried, it may be less, but shall not be more, than the maximum given in Tables at foot.¶ It shall be fixed in the boat after measurement immediately over the centre of gravity of the yacht, and shall not afterwards be removed. Its weight shall be checked by the measurer and noted on the certificate.

MEASUREMENT

This shall be carried out in salt water of a specific gravity of 1.025. Yachts may be measured in fresh water, in which case their ratings may be increased to the allowed limits. Yachts measured in fresh water may weigh $1/36$ th less than the weight given for the corresponding L.W.L. taken in salt water. No adjustment is necessary in the Table of Draughts. All the minimum displacements and maximum draughts given in the Tables are to be taken as without crew.

SAIL AREA MEASUREMENTS

Note.—All points of measurement of sails shall be marked on spars by a black band $\frac{1}{8}$ in. wide.

Gaff Mainsail, or Gunter Lug, whose head makes an angle with the luff. (See Fig. 3 (a) and 4 (c).)

A. Measured from the top of the extreme outboard end of the boom at the black band beyond which the sail may not be extended to the underside of the extreme outboard end of the gaff at the

|| Maximum Height for Boom.
12-m.—5.08 in.
6-m.—6.01 in.

¶ Crew Weights.
12-m.—crew of 10 persons taken as 14 oz.
6-m.—crew of 5 persons taken as 2 lb. 0 oz.

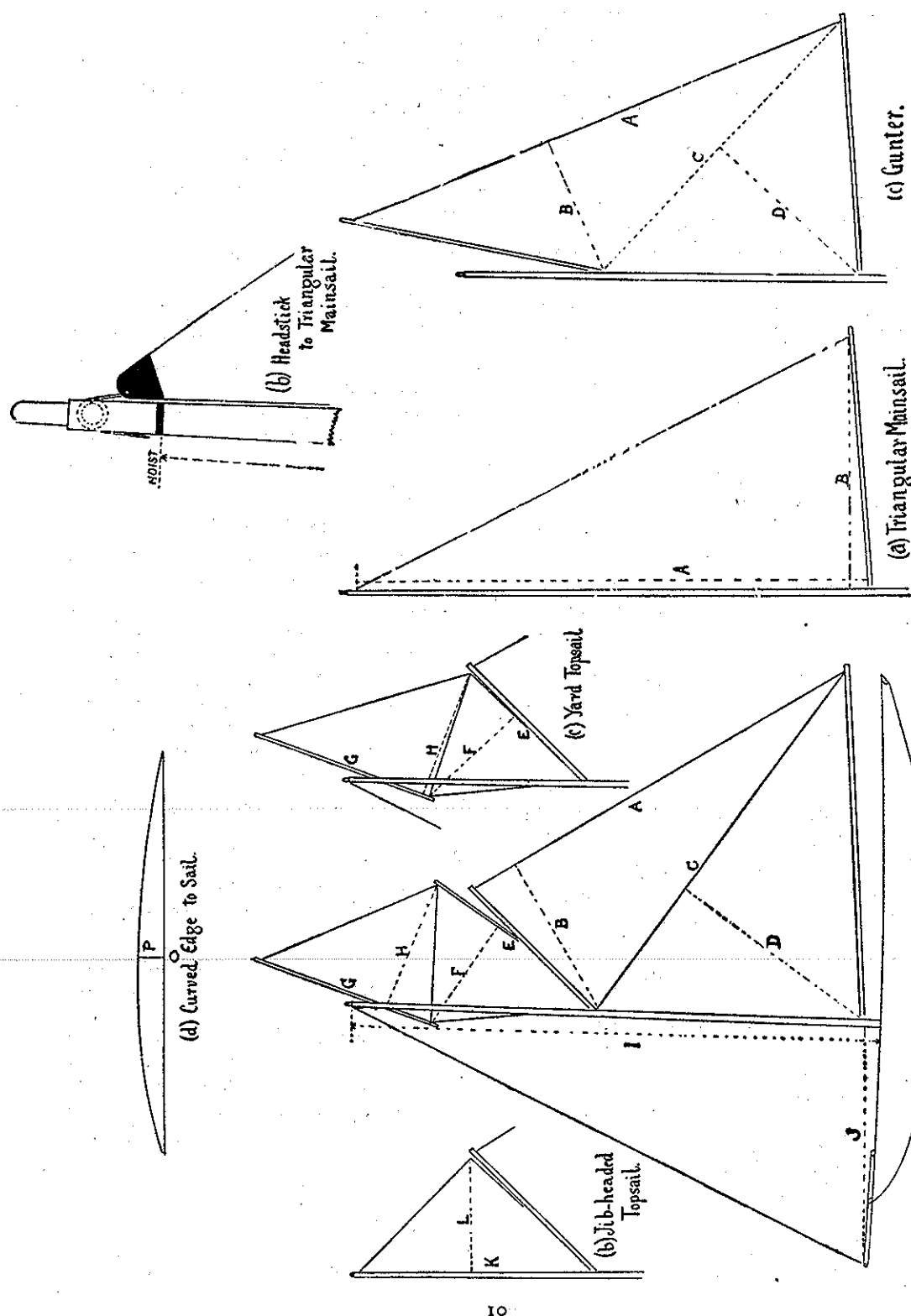


FIG. 4.

(a).
FIG. 3.

SAIL MEASUREMENT

black band beyond which the sail may not be extended.

- B. Perpendicular to A, measured to the black band on the mast above which the throat cringle of the mainsail may not be hoisted.
- C. Measured from the top of the boom at the lower end of A to black band on the mast at the throat cringle.
- D. Perpendicular to C measured in to the mast in a line with the top of the boom, or to the tack cringle of the mainsail, if below the top of the boom.

Yard Topsail. (See Fig. 3 (a) and (c).)

- E. Measured from the black band on the mast above which the throat of the mainsail may not be hoisted to the black band on the outer end of the gaff beyond which the sail may not be extended; or to the black band on the outboard end of the jackyard.
- F. Perpendicular to E, measured to black band at the lower end of yard.
- G. Length of yard between black bands.
- H. Perpendicular to G, measured to black band on outer end of gaff or jackyard.

Jib Header. (See Fig. 3 (b).)

- K. Measured from the black band on the mast above which the throat of the mainsail may not be hoisted to black band on the topmast above which the sail shall not be hoisted.
- L. Perpendicular to K, measured to black band at extreme outboard end of gaff or jackyard.

Lugsail.

To be measured the same as a gaff mainsail except as follows:—

- B and C. Forward end measured to black band at lower end of yard.
- D. Lower end measured to tack cringle of mainsail, if below top of boom, or forward of mast.

Triangular Mainsail. (See Fig. 4 (a).)

- A. The luff, measured from top of boom at after side of mast (or from tack cringle if below the boom) to the black

band on the mast beyond which the headstick shall not be hoisted.

- B. Diagonal measured from the top of boom at black band at outboard end beyond which the sail may not be extended to the nearest point at the after side of the mast.

Headboard and battens may be used as per regulations given under the Restrictions.

Headsails. (See Fig. 3 (a).)

- I. The hoist I to be measured from the deck up the foreside of the mast to the black band where the line of the luff of the foremost headsail cuts the mast.
- J. The base J shall be measured from the foreside of the mast to where the line of the luff of the foremost headsail, when extended, cuts the deck, bowsprit or other spar (excluding the club to which the sail may be laced) as the case may be. Where a mast slide is fitted, the centre of the mast must be marked on deck, and the distance from stem-head recorded on the certificate. The mast may be moved forward or aft not more than $\frac{1}{2}$ in. from the marked position, provided limits of movement are marked on deck. The base of the fore-triangle shall be marked on the deck, bowsprit or other spar. Should the mast be moved, the base of the fore-triangle shall be adjusted so that the measured base is not exceeded. Limits of movement shall be marked on deck, bowsprit or other spar as the case may be.

Spinnakers.

- I. The hoist I shall be taken from the deck up the foreside of the mast to where the line of the luff of the spinnaker cuts the mast.
- J. The base J or length of perpendicular shall be found by setting the sail taut with the heel of boom pointing towards the mast, and measuring along the top of the boom where it is cut by the line of luff to the centre fore-and-aft line of mast.

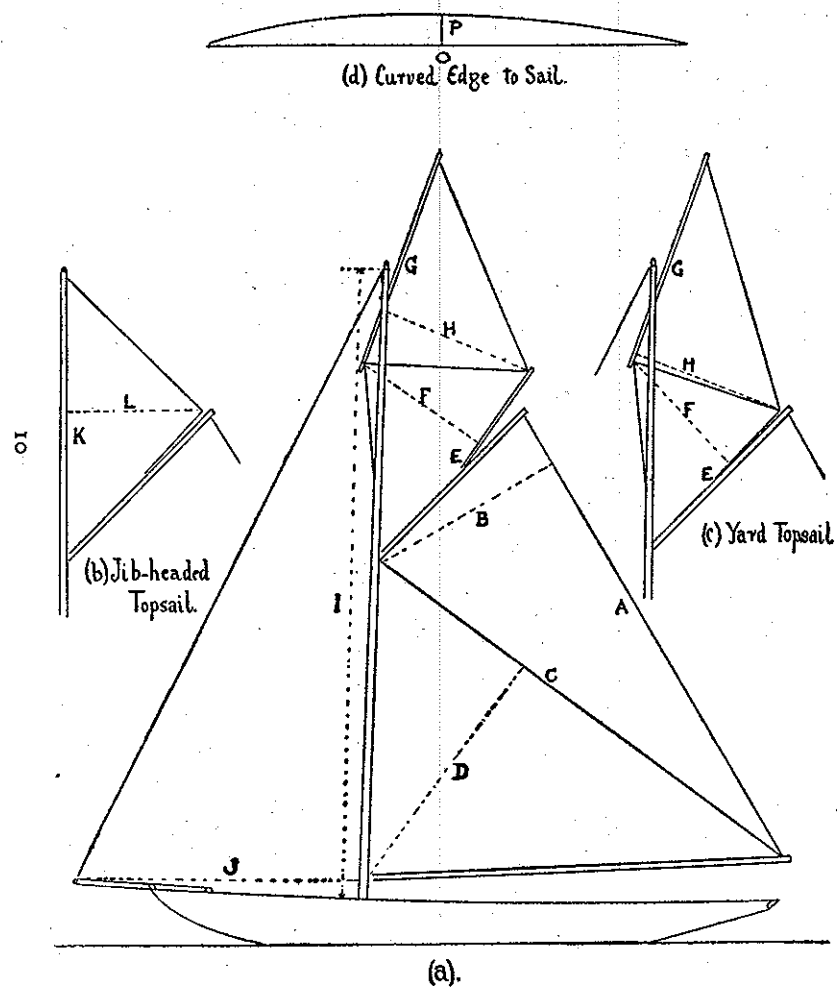


FIG. 3.

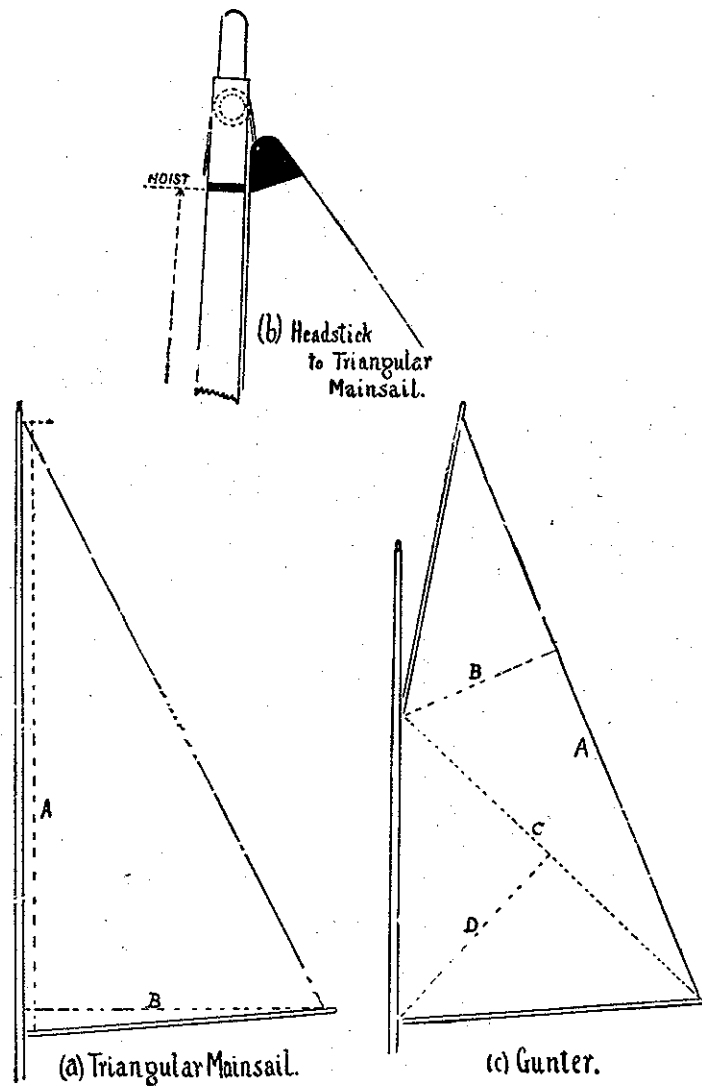


FIG. 4.

MODEL SAILING CRAFT

A spinnaker may have a headstick or board not larger than one-twentieth ($1/20$ th) the length of the spinnaker boom, but not a foot-yard, nor more than one sheet, nor any contrivance for extending the sail to other than a triangular shape, and must not be so set as to increase the measured area of the fore-triangle.

N.B.—The spinnaker sheet shall not be led round the luff of the foremost headsail.

The spinnaker boom shall not be used as a bowsprit by being tacked or fixed down at the outer end when the boom is right forward. A spinnaker may be set in the ordinary way as a balloon jib by setting it as a bowsprit spinnaker on the bowsprit, or by tacking it at the ordinary place on deck.

The spinnaker boom must be shipped and used only on the opposite side to the main-boom. A spinnaker must not be set without a boom.

No jib or spinnaker shall be sheeted on the main-boom. No contrivance such as an outrigger shall be used on the sheet of the spinnaker or any headsail.

In the case of a schooner, the base and hoist shall be measured on the foremast, but if the main spinnaker exceeds the before-mentioned measurements, this excess shall be added to these for computation of area of the fore-triangle.

In the case of a model yacht having no headsail but carrying a spinnaker, the area for the headsail shall be computed from the spinnaker hoist and length of the spinnaker boom.

Note.—Should the spinnaker hoist or boom as measured exceed the dimensions of the fore-triangle, any such excess shall be added to the dimensions of the fore-triangle for calculation of area.

In the case of a yacht carrying a square sail or square topsail, or raffer, together or separately, the actual areas of the same shall be computed; and if such area exceed the area of the fore-triangle, the excess shall be used in the total area for determining the rating.

If a square sail is used, it must be set between the mast and headsail, or aftermost headsail if more than one is used.

Foresail of Schooners.

To be measured and calculated as mainsail of similar shape.

CALCULATION OF SAIL AREAS

Gaff Mainsail or Lug. (See Figs. 3 (a) and 4 (c).)

Multiply A by B and C by D; add the products and divide by 2.

Bermudian Mainsail and Sliding Gunter whose head is in the same straight line as the mast. (Fig. 4 (a).)

Multiply A by B and divide by 2.

Yard Topsail. (See Figs. 3 (a) and (c).)

Multiply E by F and G by H; add the products and divide by 2.

Jib-Header Topsail. (Fig. 3 (b).)

Multiply K by L and divide by 2.

Headsails. (Fig. 3 (a).)

Multiply I by J and divide by 2. Multiply by 0.85 to find the area used for formula.

Lugsails and Headsails.

No deduction is to be made from headsail area on the score of any portion of the lugsail area before the mast.

Sails bounded by Curved Edges. (See Fig. 3 (d).)

Except as provided in the case of the leach of mainsail and in the case of the rounded foot of a mainsail that is not laced to the boom, any increase of sail area due to bent or curved spars, or curved edges extended by battens, shall be computed and added to calculations for rating.

The base O shall be multiplied by two-thirds of the perpendicular P.

RAKING MASTS

The measurements for headsails and spinnaker shall be taken exactly the same as in the case of a vertical mast.

SMALL SUIT SAILS AND SPARS

Small suits of sails need not be the same shape as the full suit, provided that no dimension exceeds the limits of the full-sized suit.

Spars for small suit sails shall be the same size as those used for the full suit.

THE I.Y.R.U. RATING RULE

UNITS OF MEASUREMENT

Linear.—Inches and decimal fractions of an inch.

Square.—Square inches and decimal fractions of square inches.

Weight.—Pounds avoirdupois (lb.) and decimal fractions of a pound.

All measurements beyond the second place of decimals shall be disregarded.

MARKS FOR MEASUREMENT

Sails.—All points of measurement of sails shall be definitely marked on spars by a black band $\frac{1}{8}$ in. wide.

Hull.—The ends of the L.W.L. shall be marked by vertical marks $\frac{1}{8}$ in. wide and $\frac{1}{2}$ in.

high, having their outer edge at the L.W.L. ending.

The ends of the measured length (L in formula) are marked with similar marks.

Upper and lower points of *d* measurement (i.e., on covering board and 12.5 per cent. of Class Rating below L.W.L.) with a round dot having its centre at 0.55 L.W.L.

Upper points of bow and stern tax measurements (i.e., 5 per cent. of rating above forward end of measured L, and covering board above after end of L) with similar dots.

Immersion marks at waterline at position of *d* and midship Freeboard measurement to be an inverted triangle having its apex on L.W.L. The lower angle to be a right angle and the top side of the triangle to be $\frac{3}{8}$ in. long.

Note. At the time of writing the revised I.Y.R.U. Rating Rule as given above was not finally approved by the Model Yachting Association.

CHAPTER II

A Short History of Model Yachting as an Organised Sport, and its Influence on Rating Rules. International Racing. The A-class. The M-class (Marblehead). The 36-inch Restricted Class.

THE classes dealt with in our last chapter are to rules originating with full-sized yachts, but, in addition, there are other classes to rules which have never been used for anything except models. These are the A-class, M-class, and the 36-in. Restricted Class. As the origin of these is connected with the history of model yachting, it is advisable to commence by giving a short summary of this.

Although model yacht clubs were in existence about seventy years ago, there was no attempt at national organisation. In fact every club had its own code of sailing rules and racing classes, with the result that inter-club racing was practically impossible and model yachtsmen rarely journeyed beyond the confines of their own pond. The first to attempt to organise a national authority was Mr. G. Colman Green, then Secretary of the Norfolk and Norwich Model Yacht Club. Mr. Colman Green started to form a British Association. This made a certain amount of headway but dropped when Mr. Green went abroad on business a few years later.

Another important event which occurred about 1900 was the discovery by Mr. George Braine (a member of the Model Yacht Sailing Association, a famous club with headquarters at the Round Pond, Kensington), of the steering gear which bears his name. This gear, with slight modifications, is in use at the present time, and with its discovery model yacht racing, from being a chancy sort of business, became possible as a serious sport.

In 1911 the Model Yacht Racing Association came into being. It was composed of about a dozen clubs, mainly in and around London, and catered mainly for the 10-rater class. It continued to function until the War.

During the War organised model yachting came to a standstill, though there was a certain amount of sailing in various places.

In due course the M.Y.R.A. was re-started after the War, but in 1923 it was entirely re-organised and reconstituted as the Model Yachting Association. The first chairman was the late Mr. G. Stansfeld Hicks, who remained in office for two years. He was succeeded by Mr. H. B. Tucker, who held office for five years and then retired owing to pressure of other work. When it was re-organised, the Association consisted of under a dozen clubs, but by 1930 there were over fifty affiliated clubs situated in England, Ireland, Scotland, Wales and the Dominions. The present chairman is Mr. E. Ambrose, and the number of affiliated clubs has grown to well over eighty.

The rise of the sport in popularity can largely be ascribed to the great interest created by the International Races held since the War, and no history of the sport would be complete without some mention of these.

The first international model yacht race was held in 1913 at Enghein-les-Bains, near Paris, between teams of three boats, representing Belgium, England and France respectively. The yachts used were to the 80-cm. Class.

This rule was of Continental origin, and is the same as the 1908 I.Y.R.U. with the free-board omitted. These little craft for a while enjoyed a certain amount of popularity with those who favour a small boat on the ground of portability.

The British team in these races consisted of Messrs. W. T. Vines, W. J. Daniels and A. W. Johnson, and it successfully defeated the other nations. Mr. Daniels further distinguished himself by winning the prize for the highest individual score. This consisted of a handsome Sèvres vase, presented by the then President of the French Republic, M. Poincaré.

The next international contest was after the War, in 1922, and was the result of a challenge

issued by Mr. W. J. Daniels to any model yachtsman in the United States to meet him in a series of races. The conditions of this contest called for the use of models to the American B-class, and the races were sailed from skiffs. For the event Mr. Daniels built "Endeavour," and took her to the States to meet the selected American craft. His opponent was "Polka Dot," Mr. A. E. Bull. The American boat was successful in these races, but the effects were probably more far-reaching than if "Endeavour" had won, as the present series of international races was the direct outcome of a promise to give him a return match.

On his return from the States, Mr. Daniels interviewed Sir Edgar Mackay, who about this time acquired the *Yachting Monthly*, and suggested that this race would be an excellent opportunity to try out a new Rating Rule suitable for full-sized yachts, which should contain the best features of the B.R.A. Rule of 1920 and the American Universal Rule, in the hope that if this new rule was successful, it might ultimately be adopted on both sides of the Atlantic. In formulating the rule, Major M. Heckstall Smith, originator of the B.R.A. Rule, was consulted.

The upshot of this was the offer of the first *Yachting Monthly* Cup, by the proprietors of that magazine, for international competition with models to a new formula which was at first known as the *Yachting Monthly* Rule. This first Cup was a Challenge Cup which could be won outright by three wins.

A challenge having been received from the Royal Danish Yacht Club, the first contest for this handsome trophy took place on the Gosport model yacht lake in 1923. In order to select the British representative, a Selection Race was held, and after a strenuous contest the honour was gained by "Invader" (Mr. J. Scott Freeman, Staines Model Yacht Club, designed, built and skippered by Mr. W. J. Daniels). In the international event "Invader" had a very easy victory over the Danish representative.

The following year Denmark again challenged with a new boat, and again the British boat was found by Selection Races. Once

more Mr. J. Scott Freeman, of the Staines Club, secured the honour with a new boat. This was the celebrated "Crusader," designed, built and skippered by Mr. Daniels, and once again the British boat scored a comfortable win in the International Races.

In 1925 Denmark did not enter, but a new Challenger appeared in "Slipper," designed, built, owned and sailed by the veteran American model yachtsman, Mr. Joe Weaver, of the Central Park Model Yacht Club, New York. As had now become customary, the British representative was chosen by Selection Races, and for the second time "Crusader" proved the winner. In the International Races she again had an easy victory over her American rival, and by securing the Cup for the third time Mr. Daniels won it outright for Mr. Scott Freeman.

A new Cup was given in 1926 by the proprietors of the *Yachting Monthly*, but this is a perpetual Challenge Cup and cannot be won outright. In this year, instead of being a duel in the International Races, there were three entrants beside Britain. The history of this and subsequent races can be seen from the Table of International Results included in the present chapter.

An analysis of the results shown in the Table reveals some interesting facts. Of the sixteen races held since the series was started, Britain has won fourteen, the other two having been won by Norway. No less than nine different nations have entered for these races at one time and another, but only Britain has been represented in every one. Looking at the table of winning yachts, it will be noticed that during the sixteen years of this competition Mr. W. J. Daniels has designed the winner on eight occasions, while Mr. Reg. Lance and Mr. Sam. O. Berge have each done so twice. Mr. W. J. Daniels has skippered the winning boat seven times, Mr. A. Jones three times, and Mr. R. Jurd and Mr. Sam. O. Berge twice each.

During the period under review two other international regattas have been held. The first of these was the Chicago Regatta of 1933. In this event the British representative, "Dawn," designed and sailed by her owner,

MODEL SAILING CRAFT

RESULTS OF INTERNATIONAL RACES, 1923-1938.

Year	Winner	Runner-up	Other Entrants			
1923	Britain 32	Denmark 8	—	—	—	—
1924	" 29	" 11	—	—	—	—
1925	" 61	U.S.A. 19	—	—	—	—
1926	" 93	" 81	France 45	Denmark —*	—	—
1927	" 129	" 128	Germany 47	France 44	Sweden Ser.	—
1928	" 107	" 105	France 49	Germany Ser.	" Ser.	—
1929	" 150	" 123	" 73	" 53	Belgium 51	—
1930	" 145	" 90½	" 73½	Belgium 51	Latvia Ser.	—
1931	" 114	" 99	Belgium 92	France 55	—	—
1932	" 91	" 41	" Ser.	" Ser.	—	—
1933	" 92	" 38	" Ser.	" Ser.	—	—
1934	" 91	" 34	—	—	—	—
1935	Norway 88	Britain 82	France 47	Germany 43	U.S.A. 40	—
1936	Britain 104	Norway 83	" 76	U.S.A. 72	Germany 15	—
1937	Norway 76	Britain 73	" 61	Sweden 41	Belgium 31	Germany 26†
1938	Britain 91	Sweden	—	—	—	—

* Retired on third day when her score was 87.

† Did not start on first day.

WINNERS OF INTERNATIONAL RACES, 1923-1938.

Year	Yacht	Owner and Club	Skipper	Designer
1923	"Invader"	J. Scott Freeman, Staines M.Y.C.	W. J. Daniels	W. J. Daniels.
1924	"Crusader"	"	"	"
1925	"	"	"	"
1926	"Defiance"	Capt. F. W. Lazell, Forest Gate M.Y.C.	Owner.	"
1927	"Gertrude"	R. Jurd, Gosport M.Y.C.	"	Dr. A. Thompson.
1928	"Little Nell"	A. Jones, Gosport M.Y.C.	"	Reg. Lance.
1929	"Albion"	G. Harvey and W. J. Daniels, Serpentine M.Y.C.	W. J. Daniels	W. J. Daniels.
1930	"	L. G. Rudd, Y.M. 6-m. O.A. (Surbiton)	"	"
1931	"Hermione"	T. H. Willey, Y.M. 6-m. O.A. (Surbiton)	Owner	Owner.
1932	"Flame"	A. Jones, Gosport M.Y.C.	"	Reg. Lance.
1933	"Glengarry"	Lt.-Col. Ian Dennistoun, Bedford M.Y.C.	W. J. Daniels	W. J. Daniels.
1934	"	"	"	"
1935	"Prinz Charming II."	Sam. O. Berge, Norsk Modelseilforening	Owner.	Owner.
1936	"Lady Nell"	A. Jones, Gosport M.Y.C.	"	W. H. Davey.
1937	"Prinz Charming II."	Sam. O. Berge, Norsk Modelseilforening	"	Owner.
1938	"Seri"	R. Jurd, Gosport M.Y.C.	"	Adml. A. Turner.

Mr. W. H. Davey, of the Bourneville M.Y.C., had to meet the pick of the American A-class models. The race was won by "Bostonia III." (J. Cawthra), and the British boat finished seventh in a fleet of ten.

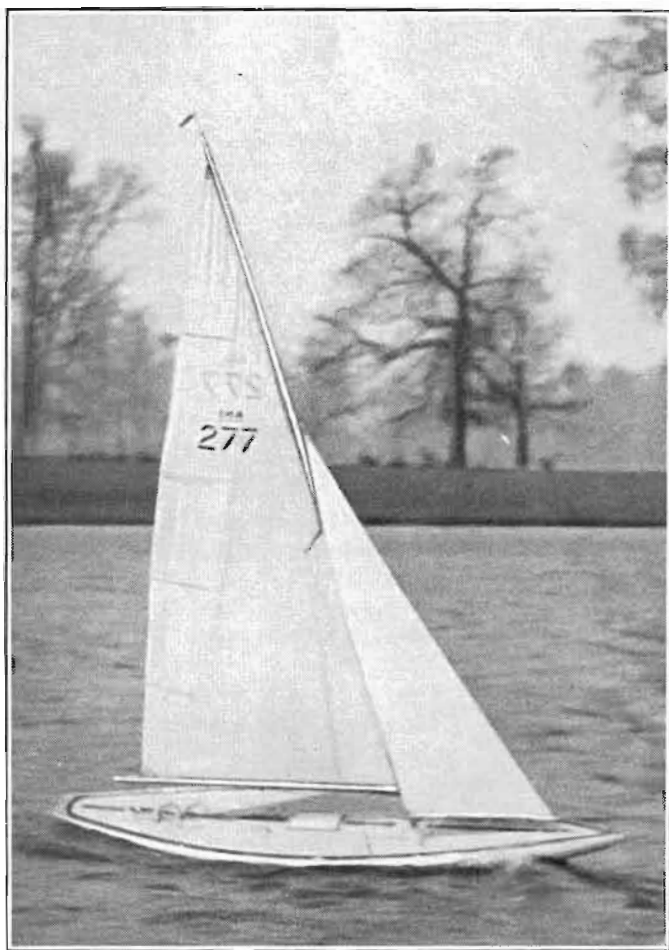
When the Olympic Games were held in Germany in 1936, the Deutscher Segler Verband (Modellsegel-Abteilung) staged an Olympic Model Yachting Regatta at Hamburg.

Races were held for the A-class and M-class. In the A-class two British, one American and two German models competed. The winner was "Fusilier," Lieut.-Colonel Ian Dennistoun, Britain, which was designed and skippered by Mr. W. J. Daniels. The other British yacht finished second, followed by the American and two Germans.

In the M-class the winner was "Cheerioh,"



"GLENGARRY" (LT.-COL. IAN DENNISTOUN, BEDFORD M.Y.C.),
WINNER INTERNATIONAL RACES, 1933 AND 1934.



"GLENGARRY" (LT.-COL. IAN DENNISTOUN, BEDFORD M.Y.C.),
WINNER INTERNATIONAL RACES, 1933 AND 1934.

Mr. John Black, America, designed and skippered by her owner. Two German, a British and a Danish model finished in the order named.

A most important event, which took place in 1927, was the organisation of the International Model Yacht Racing Association by Mr. H. B. Tucker, who acted as its Secretary for several years. The member-nations were Belgium, Britain, France, Germany, Latvia, Norway and the U.S.A. The I.M.Y.R.A. adopted the class of yachts used for the *Yachting Monthly* Cup races as the International A-class. Unfortunately, during the severe financial crises of 1931 and the succeeding years, the Association practically lapsed, so in 1936 a fresh international body was constituted as the International Model Yacht Racing Union. The members of this are Belgium, Britain, France, Germany, Norway, Sweden and the U.S.A. It has now adopted the M-class (Marblehead) and I.Y.R.U. 6-metres as additional classes for use in international racing.

Of the three classes—A-class, M-class and I.Y.R.U. 6-metres—recognised for international racing, only the rule for the 6-m. has so far been given, so we will now deal with the others.

THE INTERNATIONAL A-CLASS

The original idea of this class was to be a model of a 6-m. yacht to the new rule propounded for the *Yachting Monthly* Cup races on a scale of 2 in. = 1 ft., but as no allowance for crew weight was made it was not a true scale model in the sense that the I.Y.R.U. model classes are. In order to eliminate unnecessary complications for model yacht designers, the rule is now stated purely as a formula for models, and yachts of the A-class must not exceed 1 metre (39.37 in.) by the following formula:—

$$\frac{L + \sqrt{S}}{4} + \frac{L \sqrt{S}}{12 \sqrt[3]{D}} = \text{Rating.}$$

Where L = Load water line length in inches plus $\frac{1}{2}$ any excess in Quarter Beam Measurement.

$\sqrt{S}$ = The square root of the total sail area in square inches measured in accordance with I.Y.R.U. regulations.

$\sqrt[3]{D}$ = The cube root of the displacement of the model in cubic inches, in full racing trim with largest suit of sails, including spinnaker or other running sail.

Load Water Line Length (L.W.L.), is the distance in a straight line between the points farthest forward and aft in the plane of flotation in full racing trim.

Load Water Line Beam is the extreme breadth in the plane of flotation.

Quarter Beam Measurement is the quarter beam length (Q.B.L.) measured in a line parallel with the middle fore-and-aft vertical plane (or centreline), at a distance from it equal to one-quarter of the load water line beam, and one-tenth of this breadth. (L.W.L. beam) above L.W.L.

Excess of Quarter Beam Measurement is the amount by which the Q.B.L. exceeds the length allowed without penalty. This length is equal to a percentage of the L.W.L. length found by subtracting the square root of half the load water line length in inches from 100. (Percentage = $100 - \sqrt{\frac{1}{2} \text{ L.W.L.}}$)

Displacement in Cubic Inches is the weight of the model in pounds (pounds avoirdupois) divided by 0.037.

LIMITS AND PENALTIES.

(a) There shall be no limit to the displacement of models, but the cube root of the displacement ($\sqrt[3]{D}$) as used in the measurement formula shall never exceed one-fifth of L.W.L. (in inches) + 1, but in the event of it being less than one-fifth of L.W.L. (in inches) + 0.4, then an amount equal to the deficit up to the value of $\sqrt[3]{D}$ shall be deducted from the actual cube root for use in the measurement formula.

(b) The maximum draught shall not exceed L.W.L. $\times 0.16 + 3.5$ in. Any excess in draught shall be multiplied by 3 and added to rating.

MODEL SAILING CRAFT

(c) Average freeboard (taken at centre and at forward and after ends of L.W.L. to top of deck below rail) shall not be less than $\sqrt[3]{D} \times 0.28 + 1$. Sheer shall be a fair continuous concave curve. Any deficit in freeboard shall be added to rating.

(d) Height of sailplan above deck shall not exceed 85.3 in. Any excess shall be added to rating. Height of fore-triangle above deck shall not exceed 64 in.

(e) No hollows are allowed in the surface of the hull between L.W.L. and sheer line. Stem and stern profiles must be fair easy curves.

(f) Any local concave jog or notch in the plane measurement at either end of the L.W.L. shall be bridged by a straight line, and the L.W.L. taken to the intersection of such lines with the established L.W.L. plane. Any concavity in the stem line shall be bridged by a straight line equal to one-third of the greatest load water line beam, placed equally above and below L.W.L.

(g) The round of deck beams must not exceed $\frac{1}{8}$ in. for every 2 in. of the beam.

(h) Centre-plates, lee-boards and bilge-boards are prohibited.

(i) The number of battens in the leech of the mainsail shall not exceed four, and they shall be equally spaced. Intermediate battens shall not be longer than 7.87 in., and top and bottom battens 5.90 in. Headstick to a triangular mainsail shall not exceed 0.98 in., and any sail with a longer headstick shall be measured as a gaff sail. The headstick of a spinnaker must not exceed one-twentieth of the measured length of the spinnaker boom.

Spinnakers.—The length of luff and leach shall not exceed the height of the fore-triangle, plus 6 in. The maximum width of the spinnaker shall not exceed twice "J." The spinnaker shall be set at a height not exceeding that of the fore-triangle, whether the fore-triangle is less or equal to the maximum height allowed.

(j) Any increase of sail area, obtained by the use of intentionally bent masts and spars, will be measured as a bow and included in the sail area.

Booms.—In the case of booms other than

those round in section, half the depth in excess of 1 in. shall be added to sail area.

Masts.—If the section of a mast is greater in a fore-and-aft direction than athwartships, the difference shall be included in the area of mainsail, and of topsail.

(k) Models must always sail with masts and spars as measured.

(l) Hollow masts and spars are allowed.

(m) There are no restrictions as to scantlings or materials.

(n) Models must be measured in salt water. The weight of sea water to be taken as 64 lb. to the cubic foot.

UNITS AND MEASUREMENT.

All measurements shall be taken and recorded in inches, square inches, cubic inches and pounds avoirdupois. All decimals beyond two places shall be disregarded except for the weight and displacement.

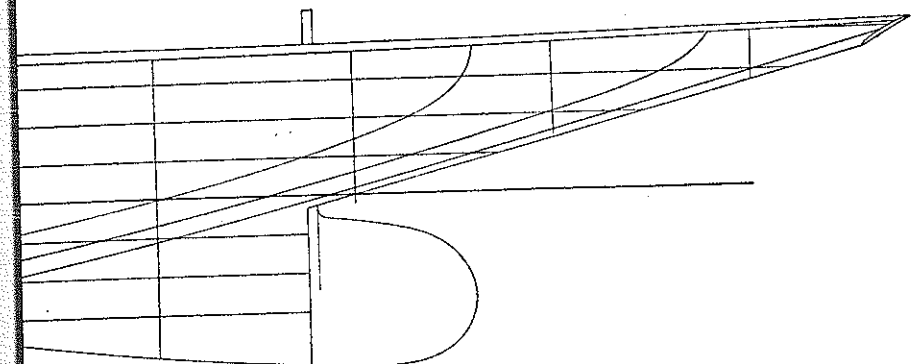
HULL AND SPAR MARKS.

The load water line shall be permanently marked at centre, and fore and after ends. Each side mark shall consist of two equilateral triangles whose apices touch at the established L.W.L. and whose bases are parallel to it. The total vertical height of each side mark shall be $\frac{1}{2}$ in. Fore and aft marks shall be $\frac{1}{2}$ in. long and $\frac{1}{8}$ in. high, and be placed so that the bottom of them indicates the position of the established L.W.L. When in racing trim, with the model floating on an even keel in sea water of the usual density, both side marks must be cut by the surface of the water.

All spars must be marked at the points of measurement with a black band $\frac{1}{8}$ in. wide.

Where a mast slide is fitted, the centre of the mast must be marked on deck and distance from stemhead recorded on certificate. Mast may be moved forward or aft not more than $\frac{1}{2}$ in. from marked position, provided limits of movement are marked on deck.

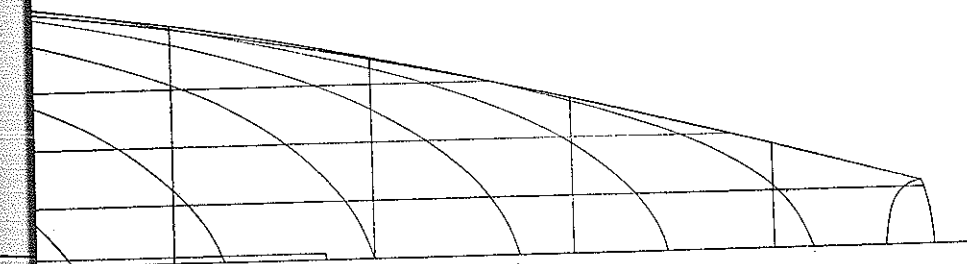
The base of the fore triangle shall be marked on the deck, bowsprit or other spar. Should the mast be moved, the base of the fore triangle must be adjusted so that the measured base is not exceeded. Limits of movement of base



INTERNATIONAL A-CLASS MODEL

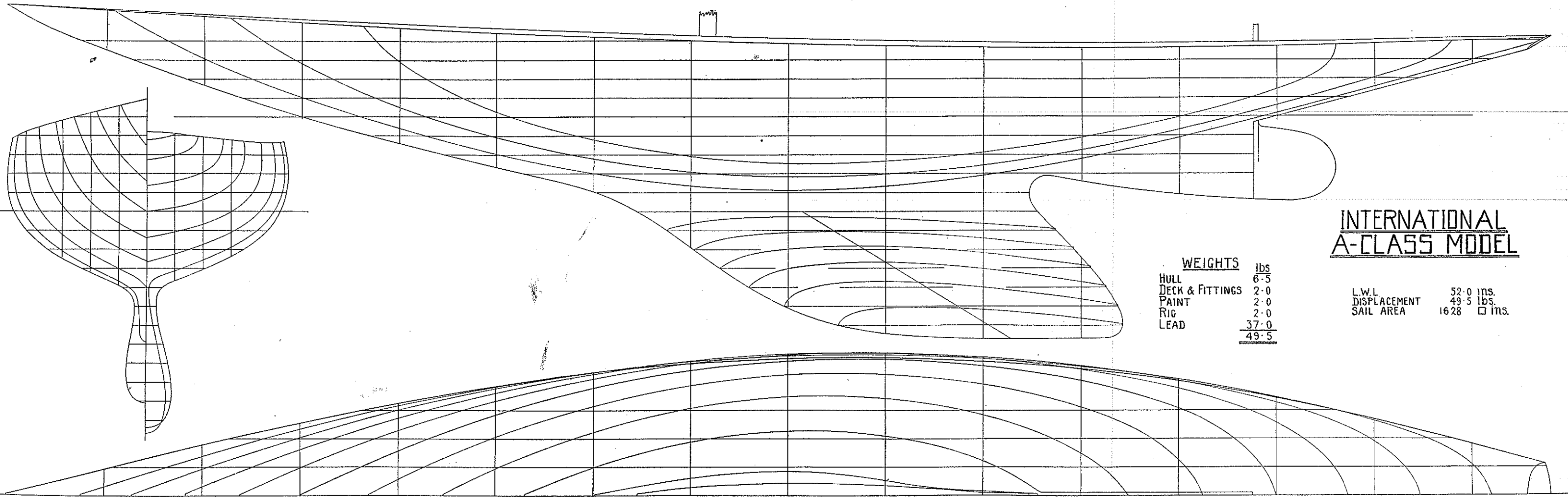
WEIGHTS	
HULL	6.5
DECK & FITTINGS	2.0
PAINT	2.0
RIG	2.0
LEAD	37.0
	<u>49.5</u>

L.W.L.	52.0 ins.
DISPLACEMENT	49.5 lbs.
SAIL AREA	1628 sq. ins.



NOTE: C.B. falls 28.7 in. abaft forward L.W.L. ending.
For Sailplan, see back of Plate.

{To face page 18.



INTERNATIONAL A-CLASS MODEL

<u>WEIGHTS</u>	
HULL	lbs
DECK & FITTINGS	6.5
PAINT	2.0
RIG	2.0
LEAD	37.0
	<u>49.5</u>

L.W.L.	52.0 ins.
DISPLACEMENT	49.5 lbs.
SAIL AREA	1628 sq ins.

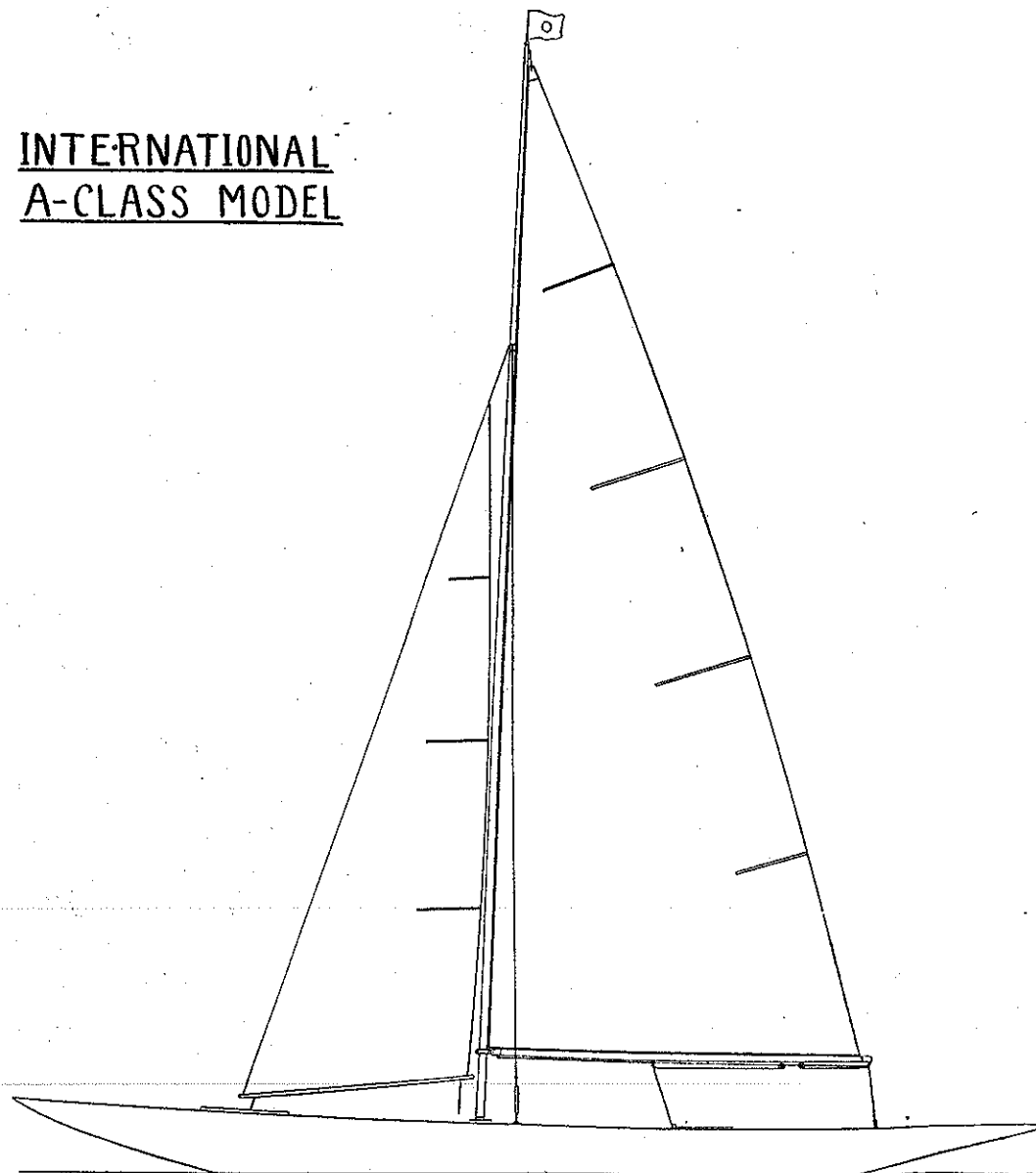
SCALE: ONE-FIFTH OF FULL-SIZE.

[Folding Plate III.]

NOTE: C.B. falls 28.7 in. abaft forward L.W.L. ending.
For Sailplan, see back of Plate.

[To face page 18.]

INTERNATIONAL A-CLASS MODEL



Mast from Bow		36-88"		
Base of Fore Triangle		18-75"		
		1st Suit.	2nd Suit.	3rd Suit.
JIB	Luff	58-5"	52-7"	46-8"
	Leach	53-5"	48-1"	42-8"
	Foot	17-75"	16-0"	14-2"
MAIN	Luff	77-0"	69-3"	61-6"
	Leach	82-0"	73-8"	65-6"
	Foot	29-5"	26-5"	23-6"

Folding Plate IV.]

[To face page 19.

THE A-CLASS FORMULA

of fore triangle must also be marked on deck, bowsprit or other spar.

The sail area is measured as under the I.Y.R.U. Rule, see Chapter I.

Rating certificates are valid for twenty-four months from date of issue, provided no alteration to hull or sails has been made in the interim.

This rule has now been in use unchanged for a number of years. Boats differing greatly in type and dimensions have been built under it, but in every case competition has been keen between the leading yachts. Models to-day are considerably larger than they were when the rule was first introduced, but this may be ascribed to the fact that designers did not at first realise the full possibilities, rather than to any fault of the formula itself.

There are a number of features in this rule that are worthy of remark. In this the American system of quarter beam measurement is used. Obviously, in a Rating Rule, if the only measurement of length is length over all, designers will not give their boats any overhangs; if, on the other hand, load water line length is taken into account without any method of checking the overhangs, designers will give long overhangs in a desire to get unmeasured length which will come into play when the vessel is sailing. Now a certain amount of overhang is desirable in a boat, generally speaking, as it gives reserve buoyancy, improves appearance, and avoids any suspicion of clubbing the deckline in forward and chopping off at the stern. Therefore, every good Rating Rule must contain some means by which the overhangs can be regulated. When any vessel having overhangs is sailing, she has a sailing waterline appropriate to her angle of heel. This is neither her L.O.A., nor her L.W.L., but something between. For the sake of convenience this may be referred to as the "sailing length," or "sailing waterline." As will be seen from the chapters on designing, length is the most important factor for speed in a yacht, and consequently in a Rating Rule, it is essential to

have a method of measuring the sailing length properly.

There are only two methods of doing this. One is by taxing the girths at the L.W.L. endings and the other by quarter beam measurement. The former method is used in the I.Y.R.U. Rule. It is a good method, but has one undesirable effect, as it tends to make the designer cramp in his deckline in order to pay as little as possible in the way of end taxes.

The quarter beam measurement, which is used in the A-class formula, may have a tendency to cause designers to make the after ends of their L.W. Lines a trifle lean. Any excess in this direction would, however, be paid for over-dearly. In the consideration of any measurement rule, it must be borne in mind that there are bound to be limits in certain directions, and that these limits must invariably have a certain cramping effect. The primary object of a Rating Rule is to measure boats fairly, and so balance the elements of speed that close racing is ensured. If the rule is such that success is attained by beauty of modelling and excellence of form, it may be claimed to be a good rule. This is done by both the A-class rule and the present I.Y.R.U. formula, and therefore both can be considered as good rules, and it is entirely a designer's own fault if he does not produce a desirable boat under either. Possibly, in some respects, the A-class formula is the better of the two. Many consider that the quarter beam measurement is a better method of measuring sailing length than end taxes. Also, in the smaller classes under the I.Y.R.U., the displacement minimum is rather high, and a finer form is possible under the A-class.

The quarter beam measurement is obtained in the following manner: a buttock is taken at the quarter beam width, in other words, midway between the centreline of the vessel and the point of her greatest waterline beam. This is known as the "quarter beam buttock." A waterline is next struck above the L.W.L. at a height equal to one-tenth of the greatest waterline beam (i.e., one-fifth of the maximum half-beam). This is known as the "1/10th beam

MODEL SAILING CRAFT

waterline." The points of intersection, forward and aft, of the quarter beam buttock and the $\frac{1}{10}$ th beam waterline are called the "quarter beam spots." The distance in a direct fore-and-aft line between these quarter beam spots is the "quarter beam length" (Q.B.L.). Another way of stating this is to say that the Q.B.L. is the distance between the quarter beam spots measured in the plane of the quarter beam buttock, or the distance measured in the plane of the $\frac{1}{10}$ th beam waterline.

It will, therefore, be seen that the Q.B. buttock and $\frac{1}{10}$ th beam waterline vary their position in direct relation to the beam.

The real novelty of the formula, however, is

any change will be made for a very long time.

* * * *

Undoubtedly the demand for a simple rule will always exist amongst a section of model yachtsmen, but in reality it is more difficult to design a yacht to a simple rule which is bound to permit exaggeration in one direction or another than to a more complicated formula which produces an all-round healthy type. Both the I.Y.R.U. and the A-class are good rules, as they give the designer every reasonable latitude and yet produce fine types of craft.

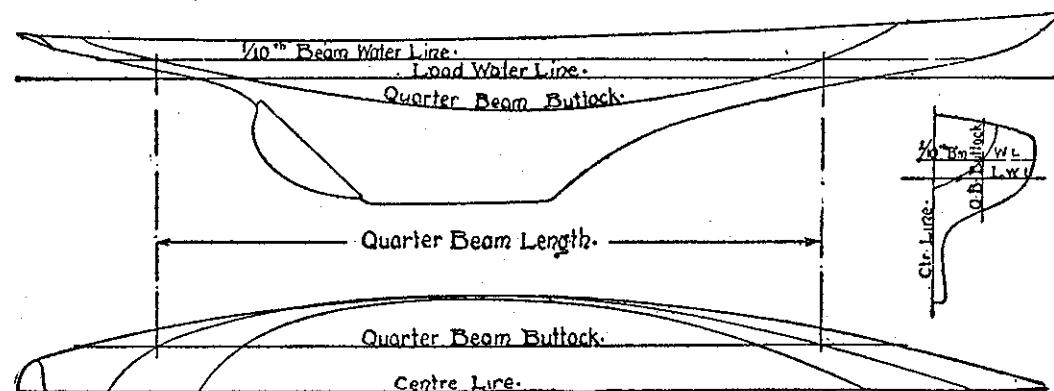


FIG. 5.—METHOD OF MEASUREMENT FOR QUARTER BEAM LENGTH.

that whereas other rules have a strong tendency in a certain direction, in this rule there are two strong forces pulling in different directions. As can be seen, the formula is divided into two parts. The first directly encourages a light displacement boat, whilst the second favours heavy displacement. The two parts are balanced against each other, and were any adjustment considered necessary, it would be an easy matter to effect by variation of the constants. So well was the rule balanced at its inception that no adjustment has proved necessary during the number of years it has been in existence. Model yachtsmen are as well pleased with the rule to-day as they were in its first year. The A-class models have proved themselves the best class that has ever existed, and it is, therefore, most unlikely that

The M-class was formulated by Mr. Roy G. Clough, of the Marblehead M.Y.C., in order to meet this demand for a simple rule. It soon became very popular in the States where it far outnumbers any other class. It was taken up by certain clubs in England, notably the Ryde M.Y.C. (Isle of Wight), and ultimately became a British National and International Class. The rule is:—

INTERNATIONAL M-CLASS.

Overall length and sail area rule.

Formula.—Overall length of hull, fifty (50) in. Sail Area not to exceed eight hundred (800) sq. in.

Exception: One quarter ($\frac{1}{4}$) of an inch in excess of or less than 50-in. overall measurement is allowed.

THE M-CLASS RATING RULE

Prohibited.—(1) Movable keels; (2) Metal fin keels or others without hollow garboard; (3) Centre-boards; (4) Lee-boards; (5) Bilge-boards; (6) Bowsprits; (7) Overhanging rudders.

Hollow of garboard shall not be less than a one inch radius. May be checked by use of a disc 2 in. in diameter fitted to garboard at midship section.

Ballast.—Weight of lead ballast must not be changed during a race or series of races. Shifting ballast prohibited.

Bumpers are not included in overall length measurement, but are limited to one-half ($\frac{1}{2}$) inch overhang.

No Restrictions on scantlings or materials.

No Limit to Displacement L.W.L., Beam, Draft, Freeboard, Tumble-home.

SAIL AREA MEASUREMENT.

No fore-triangle measurement is taken, only the *actual* sail area being measured.

Roach of sails shall not exceed 2 in. Rounded foot of loose-footed sails not measured.

BATTEN LIMITS

The battens allowed in mainsails shall not exceed four in number, and shall divide the after leach into approximately equal parts. Battens not to exceed 4 in. in length.

The battens in headsails shall not exceed three in number, and shall divide the leach into approximately equal parts. Battens not to exceed 2 in. in length.

No wire or other stiffening shall be put in head of sails.

HEADSTICKS OR HEADBOARDS.

Headsticks or headboards shall not exceed three quarters ($\frac{3}{4}$) of an inch across base.

HEIGHT OF RIG.

Height of jibstay above the deck shall not exceed 80 per cent. of the height of headboard of mainsail above deck.

SPINNAKERS.

Spinnakers are allowed.

Spinnaker poles not to exceed fifteen (15)

inches in length, measured from the centre of mast to outer end of pole.

Spinnaker must not be hoisted higher than point where jib-stay cuts the mast.

The hoist shall be measured from the deck to forestay where it cuts the mast.

A spinnaker may have a headstick not larger than three quarters ($\frac{3}{4}$) of an inch across base. It must not be set with a footyard, or more than one sheet, nor any contrivance for extending the sail to other than a triangular shape.

The spinnaker sheet may be led around the luff of headsail or forestay.

Sleeves or tubular pockets prohibited.

SAILS BOUNDED BY CURVED EDGES.

Except as provided in the case of the leach of mainsail when Batten Limits are observed, and in the case of the rounded foot of a sail not laced to boom, any increase of sail area due to bent or curved mast or other spars, or curved edges extended by battens, shall be computed and added to calculations for rating.

SAILS UNFAIRLY SHEETED OR SET.

No contrivance such as an outrigger shall be used on any headsail or upon the sheet of a spinnaker.

The spinnaker boom shall not be used as a bowsprit by being tacked or fixed down at the outer end when the spinnaker boom is right forward.

A spinnaker must not be set without a boom.

Two mainsails may not be set at the same time.

No jib or spinnaker shall be sheeted onto the main boom.

MASTS AND SPARS.

There shall be no limit to height of mast.

The greatest diameter of masts or spars are limited to three-quarters ($\frac{3}{4}$) of an inch.

There are no restrictions on material, weight, or section, and no extra measurements entailed where not round.

Hollow masts and spars are allowed.

Permanently bent masts or spars, rotating or bipod masts allowed.

MODEL SAILING CRAFT

Any increase in sail area obtained by use of bent masts or spars shall be measured as a bow and added to sail area.

Spars or masts not to be included in sail area measurements.

Raking Masts.—Measurements taken exactly the same as in the case of vertical masts.

Alternate rigs are allowed provided sail area does not exceed 800 sq. in.

THE 36-IN. RESTRICTED CLASS.

As a small simple class for waters which are not big enough for the 10-rater or 6-metres, and also for juvenile use, the M.Y.A. formulated the 36-in. Restricted Class with the following limits :—

L.O.A. (extreme)	. . .	36 in.
Beam	„ . .	9 „
Depth	„ . .	11 „
Weight (maximum)	. . .	12 lb.

Length over all does not include rudder or bowsprit.

Weight includes largest suit of sails, spars and spinnaker.

Sail area, spars and battens are unmeasured. Centreboards are prohibited.

Punts and prams (*i.e.*, boats with forward transoms) are prohibited. Box measurement is permitted, and the 36-in. Class can be measured by putting into a box with inside measurements 36 in. × 9 in. × 11 in. This permits slewing the boat to get the utmost draught possible.

CHAPTER III

Shipwrights, Ancient and Modern—An Explanation of the Lines used to Delineate a Yacht. Designing to a Rating Rule.

A PART from the *cognoscenti*, there are many model yachtsmen to whom the art of designing a yacht savours of black magic, and the lines themselves are as meaningless as the signs of the Zodiac.

In the olden days, when a shipwright designed a vessel, he took a block of wood and carved out a half-model. When he had faired this to a shape that satisfied him, he proceeded to saw the block through and took off the sections he obtained. He then went to his mould loft and laid out the sections full size from his model. The section moulds were then set up on the keel and faired up again with battens. He was then ready to build. Many a beautiful vessel was evolved in this way, and there is no doubt that many of these old fellows had a wonderful eye for a ship. Another point in their favour was that in fairing by batten they were obliged to get a natural curve. Even to-day many boats are “designed” in this manner, and some of the men who do so still style themselves “yacht and boat designers.”

This method is, however, too hit-or-miss for these modern times, and increasing knowledge has made it possible to do on paper all the old shipwright did with his half-model and a great deal more besides. Even to-day a good eye for a vessel is an invaluable possession to a designer, even as a good ear is to a musician, and just as a sheet of music is intelligible to a musician so are a yacht's lines to a designer. So, nowadays, the old shipwright's procedure is exactly reversed, and instead of making the design from the model, the model is made from the design.

The first step in designing is to understand what the lines represent. In Fig. 6 the deckline of a yacht is shown, but as the two sides of a vessel are alike, there is no need to duplicate the work, and only one side is usually shown. The craft is, therefore, considered as

if it were longitudinally cut in half by a vertical line from deck to keel. This line appears on the deckline, and is known as the “centre-line.” What has to be considered is really the lines of a half-model.

The same yacht is shown in elevation in Fig. 7. This plan is usually known as the “sheer plan,” and takes its name from the sheer, which is the side elevation of the deckline. A straight line will also be seen on this diagram, showing the line of the plane of flotation of the yacht. This is called the “load water line” (L.W.L.).

Treating the yacht as bilateral instead of as a half-model, and cutting her through horizontally on the L.W.L., a plane would be revealed shaped as Fig. 8. As, however, the yacht is being treated as a half-model, the part that is shown as a dotted line can be dispensed with. Comparing Figs. 7 and 8, the L.W.L. appears on the sheer plan as a straight line, and in plan as a curve.

In order to save space, the deckline and waterline are shown on the same plan as in Fig. 9. Other waterlines are struck at convenient intervals above and below the L.W.L., as shown by the dotted lines on Fig. 7. These are also shown on the “waterline plan,” but to avoid confusion they have not been inserted on Fig. 8.

Again considering our original deckline in plan, if a line is drawn parallel to the centre-line, as in Fig. 10, the result is a plane shaped as in Fig. 11. This line is known as a “buttock” line. In order to save space, this is shown on the sheer plan, as in Fig. 12. Other buttocks are taken out, being struck as shown by the dotted lines in Fig. 10. These also appear on the sheer plan, but for the sake of clarity, only one buttock has been shown in the diagram.

Once more, starting from our original deckline in plan, a line is struck at right angles to

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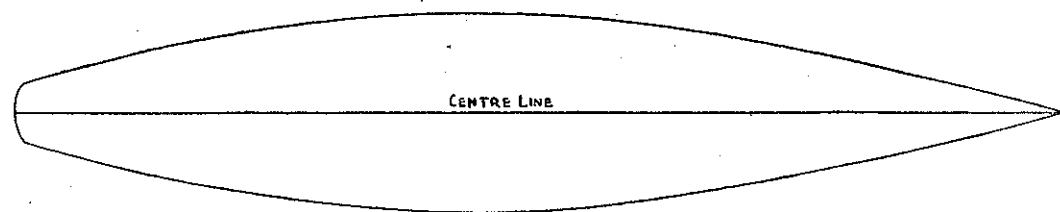


FIG. 6.

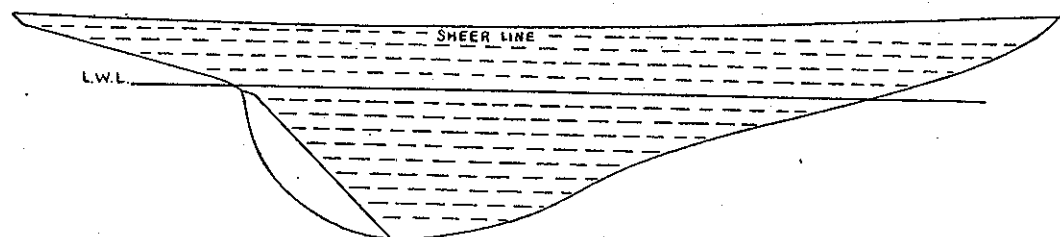


FIG. 7.

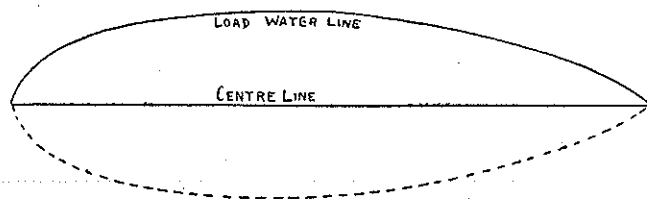


FIG. 8.

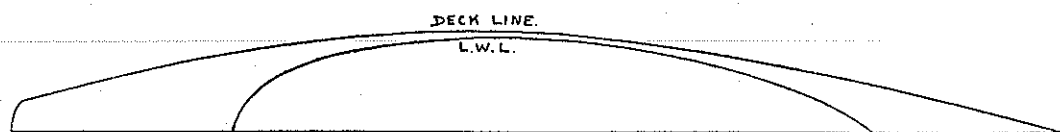


FIG. 9.

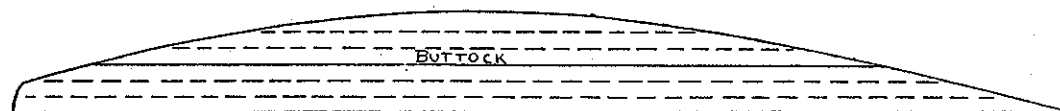


FIG. 10.

READING A DESIGN

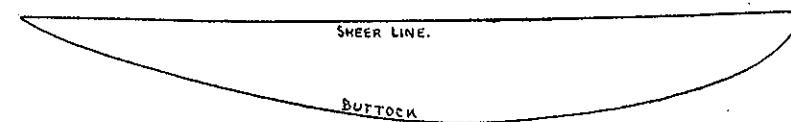


FIG. 11.

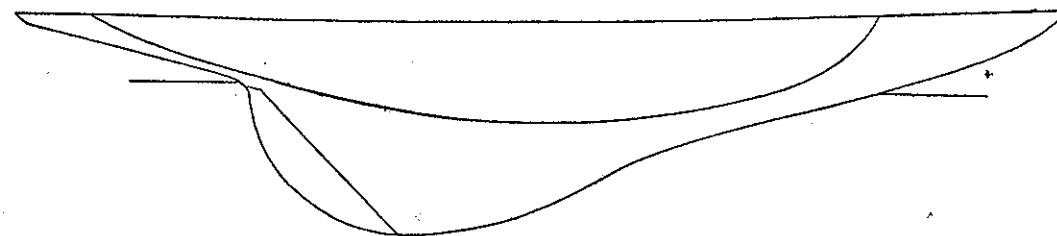


FIG. 12.

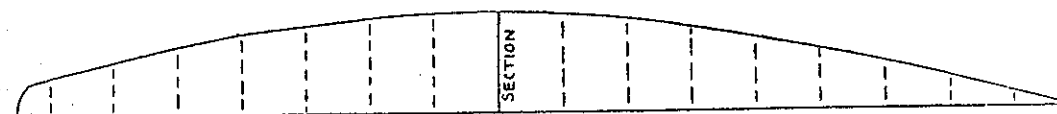


FIG. 13.

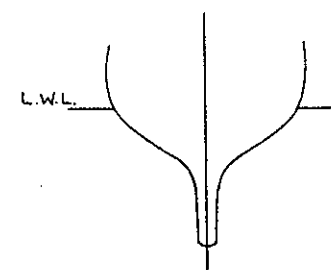


FIG. 14.

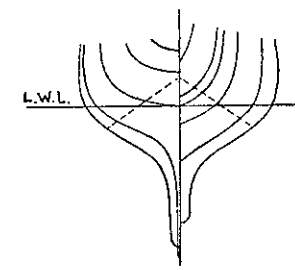


FIG. 15.

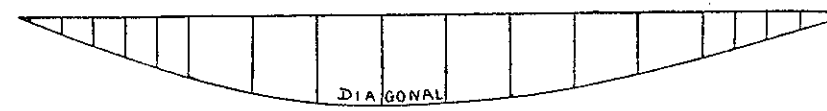


FIG. 16.

the centreline, as shown in Fig. 13. The boat is again cut through, and we get a shape as in Fig. 14. As the boat is being shown on the design as a half-model, only one half of this "section" will appear on the plans. Other sections are taken out as shown by the dotted lines on Fig. 13. These sections are plotted on the "body plan" (or "section plan"), as shown in Fig. 15. For the sake of clearness, only about half the full number of sections have been shown in the diagram. It will be noticed that on the waterline and sheer plans the sections appear as straight lines, and as curves on the section plan. Similarly, the buttocks, though not shown on Fig. 15, appear in the section plan as straight lines. The waterlines also appear as straight lines on the section plan, but only the L.W.L. is shown in Fig. 15.

The "diagonals" have next to be considered. These lines are struck on the section plan in the first instance at such angles and heights as the designer's experience tells him will be most useful. The dotted lines in Fig. 15 show one diagonal struck across the sections which appear on either side of the centreline. It may be mentioned in passing that in drawing the section plan, if the boat's bow points to the right, as in the present instance, the sections to the right of the centreline will be the forward sections, and those to the left of the centreline, the stern sections. If her bow is to the left, the reverse is the case.

There are three ways in which the diagonal can be shown, and, as will appear from the chapters on designing, the diagonals are most important features in the design of a boat. The first way in which the diagonals can be shown is in plan in their own plane. This is illustrated in Fig. 16. This plan is usually shown on the opposite side of the centreline to the waterline plan. It is plotted by measuring on the section plan up the diagonal to the centreline on each section.

The diagonals can also be shown in elevation on the sheer plan. In this case the vertical distances above and below L.W.L. on each section are plotted. The third way of showing the diagonals is in plan. In order to do this, the

distance the diagonal is horizontally away from the centreline on each section is plotted.

There are certain other lines that are used in yacht design. These are curves of areas upright and at various angles of heel. They have a large part to play in the design of a yacht, but the explanation of this must come later in this treatise, as there are a number of other points which must be dealt with first.

The above will, however, suffice to enable a tyro to set out the full-size lines from an existing design he wishes to build to.

Before leaving the subject, it would be as well to stress the point that the intersections of the various lines in the different plans must coincide. In other words, one plan checks another. If this were not so each plan would show a different boat. It is, therefore, plain that part of the work of a yacht designer consists of fairing his lines.

There is, however, a great deal more in designing a boat than merely drawing the lines and making them fair in the different plans.

Now, if one is designing a boat that is not to a particular class, the sole consideration is to produce a healthy, satisfactory craft, but if the yacht is being designed to a class, the additional consideration of producing the fastest possible boat to the rating has to be considered.

In this latter connection, it becomes largely a question of balancing the factors that are in the rule so as to get the most suitable boat for the conditions that she is likely to meet.

In modern rating rules sail area and hull dimensions both enter. It is perfectly easy to produce a light-weather craft by taking a very big sail area and small hull, or a heavy-weather boat by putting a small sail area on an outsize hull. The real skill consists of producing a boat that will do consistently well under the average conditions that are likely to be experienced.

Modern sail-plans give us greater efficiency per square inch of area, and consequently, even under the present rules, boats are larger than they were a few years ago. With larger hulls and smaller sail area, it is not necessary to have

as much natural stability in the actual shape of the hull, and consequently we are able to ease the lines and produce an easier-driven form of hull.

Before proceeding to define some of the points that a designer has to bear in mind, it must be emphatically stated that with modern rating rules it is useless to try to evade the rules

and produce a freak boat. It is possible to do this, but actually it can only be done at the expense of success. In modern yacht racing, success can only be obtained by evolving a well-balanced yacht combining sweetness of form with a correct judgment in selecting the best dimensions to fit the class for which the yacht is intended.

CHAPTER IV

General Considerations in Designing. Drawing Requisites. Midship Sections. Calculation of Section Areas (Simpson's and Trapezoidal Rules). Co-efficients of Fineness. Raked Midsections. The First Steps in Drawing a Set of Lines.

NOW, whether the yacht is being built to a class or not, the aim of the designer must be to produce a satisfactory and well-balanced craft. Before proceeding to set out methods by which this desideratum can be attained, it would perhaps be as well to enumerate some of the considerations which must guide the designer.

The design of a steamer or motor ship is less complex than that of a sailing vessel, for whereas the former is propelled by a known force upon a more or less even keel, the latter is propelled by that intangible force, the wind, which varies continually, and except when the wind is dead astern, is constantly heeled to ever-changing angles. It must, therefore, be borne in mind that the immersed portion of a sailing vessel's hull alters with every different angle of heeling and consequently her underwater shape continually changes. It follows that the design of the topsides and underwater body must form one harmonious whole, so that the craft is balanced in this particular respect. This is, however, only one of the many features that has to be studied before the yacht can be expected to perform adequately under all conditions.

Moreover, the water cannot be considered as a plane surface, as it is in a state of constant disturbance, and the yacht's form must be considered in relation to the ever-changing motion of the waves. A properly designed hull continues to traverse the crests of the seas so long as the distance between the crests does not exceed one-third of her own length. When they are greater than this, one end of the vessel will be unsupported, and a pitching and scending motion will be engendered. This makes it essential that the vessel shall be properly balanced in a fore-and-aft direction, as, if her motion does not synchronise with the timing of the waves, she will be incessantly

thrown out of her stride and stopped. She will also bury her ends and ship water on deck, making her a bad sea boat. Further, the sails will be constantly vibrated and prevented from doing their work efficiently, so that she loses speed through the water.

In making a design, the vessel is primarily considered in an upright position, as this is necessarily the basis of comparison in form. As will be explained in due course, certain centres govern the fore-and-aft trim, and it is part of the designer's work to compare their positions when the boat is heeled with their positions when she is on an even keel, and make such adjustments as may be necessary to ensure her retaining the same fore-and-aft trim under every condition. Unless a yacht does this at every angle of heel, she will refuse to hold a true course.

The importance of this point can easily be understood if the effects of alterations of fore-and-aft trim are considered. When a vessel is on an even keel, the natural axis of the hull is parallel to the waterline. If on being heeled she stoops by the head, the natural axis of the hull will no longer be parallel to the waterline, with the result that the hull will want to run off the wind, and as the boat runs off the wind she increases her speed and angle of heel. At the same time the plane of the fin, being out of parallel with the load waterline, has its leading edge pointing downward, with the result that the fin cuts downward and drags the head of the boat still further down. This not only sets up a tremendous resistance, but causes the centre of lateral resistance (C.L.R.) to move forward suddenly, with the result that the boat gripes violently into the wind. If, on the other hand, she squats by the stern, the axis will also go out of parallel, and she will at first gripe into the wind. The fin, however, will be pointing upward and lift the

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bow. The C.L.R. then moves suddenly aft, and the boat will run off the wind. Fore-and-aft balance is, therefore, a very essential feature of design.

Now, a body floating in water displaces a volume of water equal to its own weight. If a yacht was lowered into a dock that was full to the brim, the weight of water that would overflow would be of the same weight as the vessel herself.

Directly a ship starts to move forward, the level of the water ahead of her largest cross-section begins to rise, whilst the level from the largest section to the after end of the vessel is lowered. The natural tendency of water is to find its own level, and consequently the water displaced by the forward part will tend to flow round the hull and take its place astern. The fore-body is accordingly usually spoken of as the "entry" and the after-body as the "delivery." It entirely depends on the arrangement of these parts of the vessel, both separately and in relation to each other, whether this function is evenly and smoothly carried out. Hence it is essential that the fore- and after-bodies are balanced and in harmony. This is governed by the manner in which the displacement is distributed throughout the length of the vessel, or, in other words, the sections must be such that the rate at which the fore-body displaces the water synchronises with the rate at which the after-body delivers it.

In its passage through the water, the hull sets up several different systems of waves. As previously stated, the fore-body piles up the water ahead of it. The form of this bow wave will be governed by the manner in which the displacement is distributed throughout the entry. If the bow is too full, it will tend to do the work of displacement before the middle of the hull is reached. If, on the other hand, the bow is too fine, the main part of the displacement will take place too abruptly when the water reaches the middle body. It must, therefore, be the designer's aim to arrange the rate at which the displacement increases from the bow to the greatest cross-section in such a manner that the work of displacing the water is evenly distributed.

In a similar manner, the after-body sets up a separate system of waves in its work of delivering the water, and it is equally important that this function shall be similarly carried out at an even rate.

Consequently, it follows that once the fore-body of a yacht has been designed, there can be only one possible after-body that will harmonise with it. This harmony consists of delivering the water at a corresponding rate to that at which the entry displaces it. It must, however, be remembered that the fore-body has to overcome the initial inertia of the water, whereas the after-body deals with water that is already in motion, and whilst both entry and delivery have to cope with the same volume of water, the only way to ensure harmony is to make the fore-body a little longer than the after-body in order to assist it to perform its first task of setting the water in motion and thus equalise the two resistances. Experience has shown that a proportion of 11 to 9 is as nearly as possible correct in a boat of normal form.

The wave-throw of a yacht gives a very clear indication as to whether the vessel is correctly designed, as its form will demonstrate if the hull has an even rate or not. Further, a properly designed vessel will leave the water almost undisturbed when driven at normal speeds, as the crests of the stern-wave will coincide with the troughs of the bow-wave, so that the one damps out the other.

So far, only the balance of the hull proper has been referred to, but, as will be shown in a subsequent chapter, the balance and arrangement of lateral plane are equally important, as also are the relative proportions of fore- and after-sail, and the position of the whole sail plane over the hull.

In getting out the lines of a hull, it should be the designer's aim to produce the most easily driven form of hull for a given length and volume. The faster a vessel travels, the greater is the influence of a badly designed hull, as any feature that creates resistance will be accentuated at higher speeds, and will have the effect of making the yacht erratic in performance. Model sailors frequently attribute

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bad steering to faulty setting of the sails or steering gear when the *actual* trouble is an unbalanced hull.

All yacht design is more or less of a compromise, but the main essential is the elimination of vices that interfere with correct functioning, and unless a yacht is correctly balanced and in complete harmony, she will never perform in a really satisfactory manner. It is useless to introduce one badly balanced feature to try to offset another. In some cases it may be more or less a palliative, but "two wrongs never made a right," and it must always be the aim of the designer to produce a design that can be regarded as one harmonious whole. This is mainly a matter of care and calculation. If one is not prepared to take the necessary pains to ensure good results, it is better to build one of the many good designs which are published rather than build a model which is almost bound to prove a waste of time and materials.

* * * *

The simplest method of explaining the processes of designing is to take the reader through the drawing and proving of a design step by step, but before doing so it will be as well to deal shortly with the materials and implements used in draughtsmanship.

The first requisite is a suitable drawing board. If we are undertaking an A-class design, this will have to be about 7 ft. long to enable us to draw the plans full-size, or 3 ft. 6 in. for a half-sized plan. The drawing must not be on too small a scale, as it is impossible to read a plan to more than $\frac{1}{160}$ in., and an error is multiplied in the enlargement to full size. Moreover, small-scale plans are very trying to the eyes. The plans, on the other hand, should not be on such a large scale that the eye cannot take them all in at a glance as a concrete whole.

A good quality drawing paper should be used in order to stand erasures. This is pinned on to the board with a couple of sheets of cheaper paper underneath it to save the board.

For the actual drawing an HHHH pencil or

even harder grade should be used. As the designer progresses, he will find that a hard pencil finely sharpened is essential to avoid having thick lines. A good pencil eraser is also a necessity.

A long straight edge is needed, but before starting to use it, it should be carefully tested to be certain that it is dead true. A good T-square is also necessary. It should be emphasised that it is very essential that the straight lines that form the basis of the plan must be absolutely straight, and all right angles must be dead true.

For taking measurements, an engineer's rule calibrated to fiftieths of an inch will be found the best, and a good pair of dividers is also most useful.

For drawing the long curves in the design a good spline is required. For an A-class boat, 7 ft. long $\times \frac{3}{8}$ in. $\times \frac{1}{4}$ in. would be a very suitable size. This spline may be of lancewood or red pine, but whichever wood is selected, the grain must be straight and even, so as to produce a natural curve from end to end without any flats or humps. A tapered spline of a smaller size is also required.

For the shorter curves with a sharper radius, celluloid splines are excellent.

In order to hold the splines in position, weights are required. Special drawing weights are made, but for a start almost any weights that are heavy enough can be made to serve.

The use of "curves" in designing cannot be recommended, as they tend to influence the designer and make him distort his lines. They are, however, extremely useful in making an ink tracing of a design, and their use should be limited to this purpose.

In choosing a yacht as an example to design step by step, it was not considered advisable to take an extreme model to a rating class, but a small model of normal dimensions that will present a comparatively easy problem to the designer. We will accordingly take a little boat of 36 in. L.O.A. with a beam of 9 in. and L.W.L. of 28 in.

Incidentally it should be mentioned that these dimensions will give a boat that will rate

MIDSHIP SECTIONS

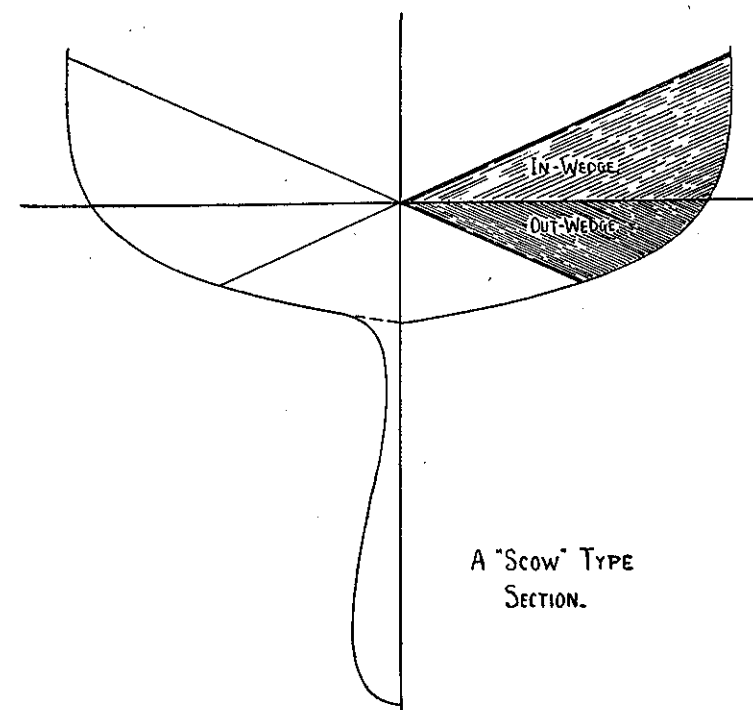
in the 36-in. Restricted Class, but if we were going to design a racer specially for the class, more extreme dimensions would be selected to take the utmost advantage of the rule.

Now, the feature which has the greatest influence on the whole design is the midship section, and as a preliminary to starting our design we will examine a few types of midships sections, and their characteristics.

It will be remembered that earlier in this

must be exactly equal in volume to the portion of the weather side that is lifted out. These two parts of the boat are known as the "immersed wedge" and the "emersed wedge" respectively, or, more briefly, as the "in-wedge" and the "out-wedge."

If the vessel were artificially heeled by moving a weight that is already on board, the above considerations would apply in their entirety, but as the craft is heeled by the wind



A "Scow" TYPE SECTION.

FIG. 17.

chapter reference was made to the axiom that a floating body displaces a volume of water equal in weight to its own weight. If this is true when a vessel is in an upright position upon an even keel, it is equally true when she is heeled. Now, it is obvious that when a vessel heels, she must lift a portion of her weather side out of the water, which is balanced by the immersion of part of her leeward side. As the weight of the vessel remains constant, whether she is upright or heeled, the part of the lee side that is immersed

and also in motion, certain other factors come into play.

The wind pressure on the sails has a tendency to heel the yacht which the lead keel strongly resists. The conflict of these two forces causes a downward thrust to be exercised on the hull, which depresses it in the water.

Reference has already been made to the functions exercised by the entry and delivery during the boat's passage through the water, and it follows clearly that the forward motion of the craft must create a trough in the water

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into which the vessel will settle, and the faster the boat is travelling the deeper will be the trough.

It will therefore be seen that a vessel is not altogether dependent upon the relation of her in- and out-wedges, but at the same time their comparison is instructive.

For the purpose of comparing the in- and out-wedges of any given section, it is usual to strike waterlines at various angles of heel

very apparent, no attempt has been made to make these sections of exactly the same area, and, consequently, the resultant boats would vary considerably in displacement.

Turning to the "scow" section shown in Fig. 17, it will be seen that a boat of this type has a great discrepancy between the areas of the in- and out-wedges. This in itself will obviously cause the boat to have a tendency to lift when heeled. At the same time the type

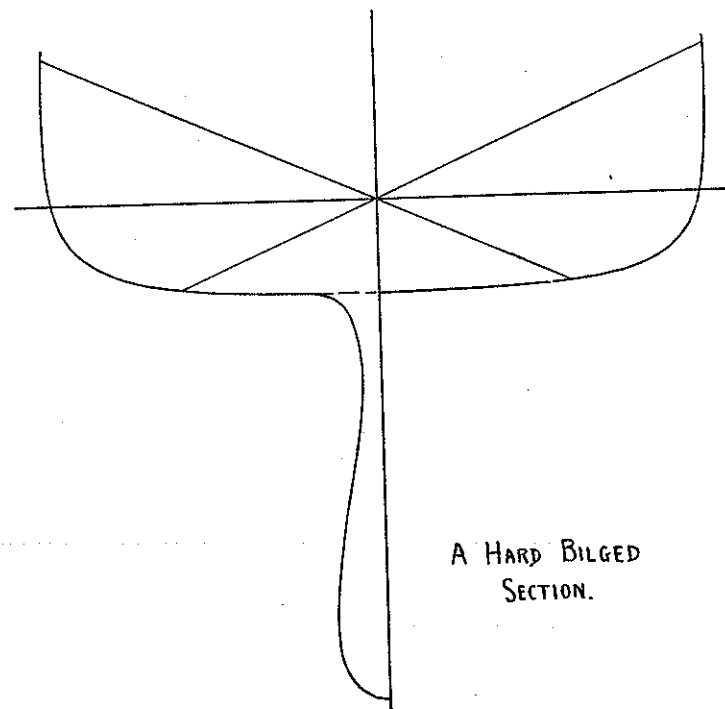


FIG. 18.

through the point of intersection of the centreline and the upright load waterline. This is, of course, not strictly accurate, and the amount by which it is inaccurate varies with the difference in area of these wedges. At the same time, it is quite near enough for all practical purposes and avoids making a large number of complicated calculations.

Now an examination of the diagrams in Figs. 17, 18, 19 and 20, showing various types of mid-section, will reveal the vices and virtues of the different forms. In order to make these

has great initial natural stability, owing to the flat floors and great beam, but the bad result of the tendency to lift will be that the further the boat is heeled, the more her natural stability will decrease. Moreover, her great beam will present a big area of windage as the weather side is lifted out, and the wind, getting underneath this, will exert further heeling pressure which will also tend to drive her bodily to leeward.

The type is, however, very speedy in smooth water when the boat is not heeled to any great

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extent, as a design with very shallow and easy buttocks can be worked out on these lines. It is a light displacement type that was originally developed under the Length and S.A. Rule.

A rather similar type of section is shown in Fig. 18, but with a greater displacement and harder bilge. Whilst apparently this section is very well balanced in respect of the in- and out-wedges, it is similarly lacking

This will be found to lie somewhere between these various types.

The section shown in Fig. 20 is what is colloquially known as "round as an apple." Many of the old boat-builders who designed their boats entirely by eye, backed by generations of experience, turned out craft of beautiful model. Amongst many of these this form of section was a great favourite. This is not to be wondered at, as it is very sea-kindly, and

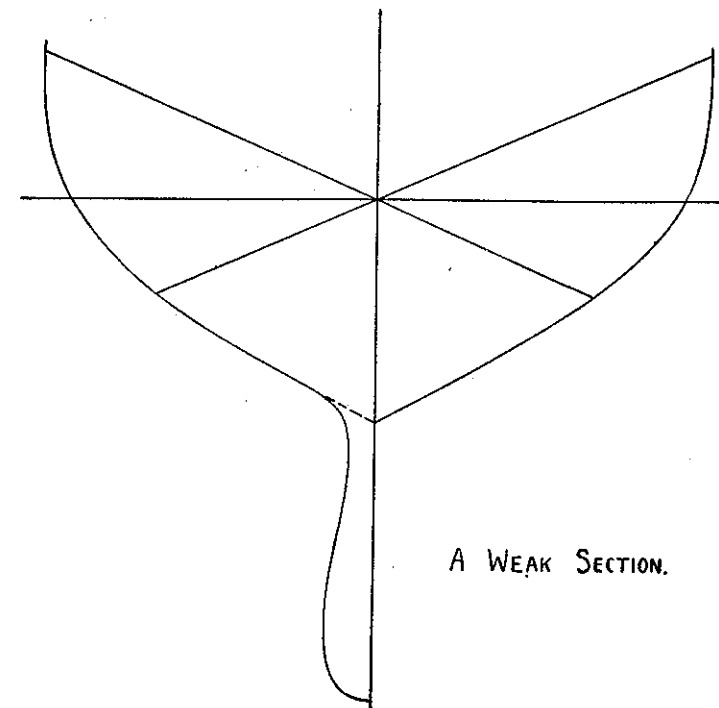


FIG. 19.

in natural stability when heeled, and, owing to the deep bilges, a craft with this section would be prone to be very sluggish in light winds.

Quite a different type of section is shown in Fig. 19. This has a very weak out-wedge and a strong in-wedge. It has very little stability, and would be easily overpowered.

It is obvious that all these are extreme types, and in yacht designing, as in most other things, the extreme is seldom successful, and what is wanted is the happy medium.

whilst of considerable stability, is also very easy in a seaway. These old builders in the main turned out fishing vessels, but this section is also most suitable for cruising yachts, where easy driving, comfort and the ability to keep the sea in heavy weather are important considerations.

When the vessel under construction is a racing yacht, speed is naturally the primary object. One of the principal factors to bear in mind is that the hull must be easily driven, and the mid-section must, therefore, be such

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that it is possible to develop an easily driven boat about it. The section shown in Fig. 21 is of this nature, and has approximately the right proportions for the boat we are going to design. Moreover, it is powerful and will give the ability to carry sail.

In order to understand the manner in which the mid-section influences the form of the whole boat, it must be borne in mind that if the boat is to maintain her correct immersed

way as she pitched, whilst the natural development of the boat represented in Fig. 18 would be a coarse-ended yacht which would be hard to drive. On the other hand, the ends of the V-section boat shown in Fig. 19 would be very weak V's. This style of boat is often fast off the wind, but becomes very wet immediately she is close-hauled, as the ends have insufficient reserve buoyancy.

The "apple" section in Fig. 20, whilst

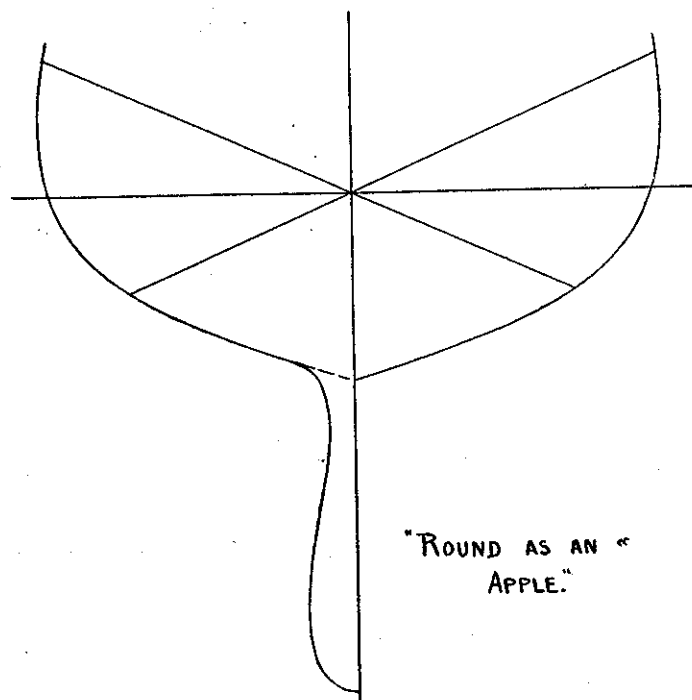


FIG. 20.

form at varying angles of heel, the sections fore and aft of this midship section must maintain this same character throughout the entire length of the craft. In other words, the ends of the vessel must harmonise with the middle. The old rule-of-thumb builders recognised this necessity and called the mid-section "the master section" and the mould for it was marked with the sign ☒.

If this axiom were properly carried out, the section in Fig. 17 would produce a flat-ended craft which would slam abominably in a sea-

producing a vessel of easy transverse motion, permits the design to be carried out to ends of moderate fullness without loss of character.

The section shown in Fig. 21 is the type which it is intended to adopt in the present design. In this it has been the endeavour to obtain the best results in consideration of the foregoing analysis, and if the design is correctly developed about this section, the resultant model should find a wide range of conditions under which she can perform creditably.

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Although the practised designer can estimate the possibilities of a section by eye, the novice may not find this easy. It is partly a question of the proportions of in- and out-wedges, strength of the bilge curve, flatness of floors, etc. A method of ascertaining the comparative stiffness of any two sections is by the use of the Metacentre, but this is explained at length later in the book, so it is now sufficient to mention it in passing.

shape as the vessel's underbody. By ascertaining the cubic content of this hole, and calculating the weight of water that would be required to fill it, we can ascertain the vessel's weight. The term "displacement," therefore, means either the number of cubic feet of water the vessel displaces, or the weight of water she displaces.

A cubic foot of fresh water weighs 62.5 lb. and a cubic foot of sea water 64 lb. Thus, if a

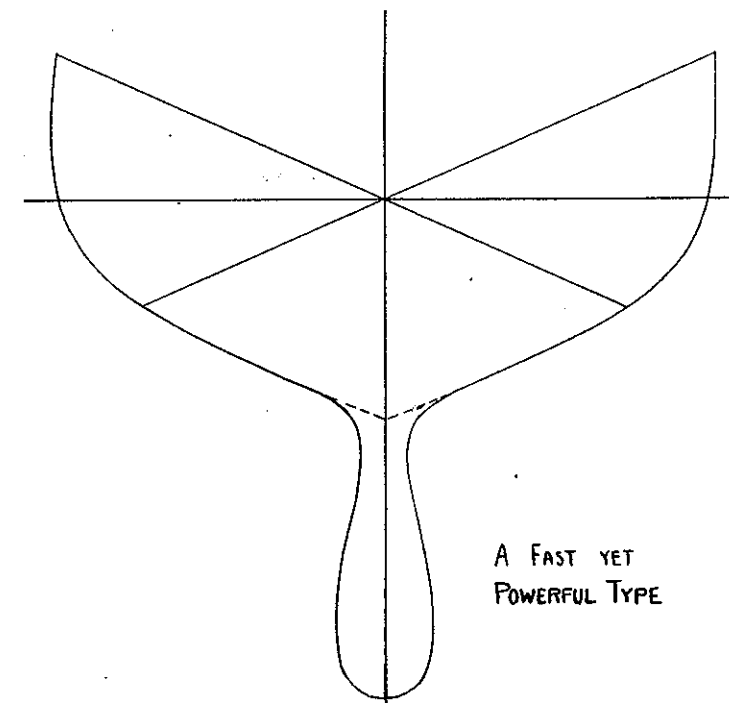


FIG. 21.

Before finally deciding on our midship section, its area must be ascertained in order to see whether a section of the selected shape and dimensions will give a suitable displacement for our yacht.

This requires a little explanation, so let us start from the beginning. As was previously mentioned, a vessel floating in water displaces a volume of water having a weight equal to its own weight. If one froze the water round a vessel and then lifted her out bodily a hole would be left in the water of the same

model displaces 1,728 cu. in. of fresh water she weighs 62.5 lb., or 64 lb. if it is sea water. Given the displacement of a model in cubic inches, the easiest method of ascertaining her weight is to divide the displacement in cubic inches by 27.65 for fresh water and by 27 for sea water.

Obviously one can thus ascertain what the weight of any yacht should be in order to float at her designed L.W.L. The first step is to be able to calculate the area of a section. We are only concerned at the moment with the

immersed portion of the section, and therefore what has to be calculated is the area of the part of the section that is below the L.W.L. By way of an example let us take the scow section we used earlier in this chapter.

There are several different methods of ascertaining this. If the drawing has been made on squared paper, one method of doing this is to count the squares, making allowance

equally accurate, the margin of difference being only about 0.5 per cent., whilst it is more convenient, as any number of ordinates, either odd or even, can be used. Moreover, it is slightly shorter and saves a little calculation. For the sake of reference, both rules are given, together with worked examples, but the young designer will find the trapezoidal rule answer all requirements.

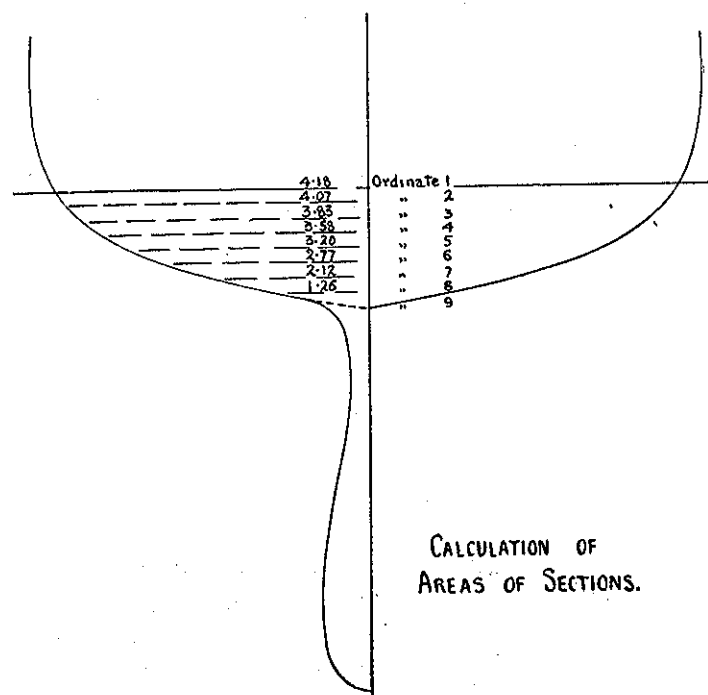


FIG. 22.

for parts of squares. If the paper is divided into inches and tenths, every large square represents 1 sq. in., and each small one $\frac{1}{100}$ sq. in.

The proper method of calculating the area of an irregularly shaped figure, such as the section of a yacht which has one face bounded by a curved line, is to use either what is known as Simpson's Rule or else the Trapezoidal Rule.

The former is more generally used by naval architects, but the trapezoidal rule is almost

SIMPSON'S RULE

The base of the figure (which in this case will be the centreline of the yacht) is divided into any convenient *even* number of equal parts, as in Fig. 22. At each of these points a line is erected at right angles, and these lines are known as "ordinates."

Add together the first and last ordinates and call the sum A; add together the even ordinates and call the sum B; add together the odd ordinates (except the first and last) and call the sum C. If the length of the base of

the figure be represented by L and the number of parts into which it has been divided is called N, then L divided by N will give the distance apart of the ordinates, which is represented in the formula by D.

Then

$$(A + 4B + 2C) \times D \div 3 = \text{Area of the Figure.}$$

This rule is not absolutely accurate, but the margin of error is reduced by taking a greater number of ordinates or, in other words, dividing the base into a greater number of parts.

Stated in this way, the rule sounds a little complicated, but in reality it is quite simple to use. For the purposes of the naval architect it is usual to set the calculation out in tabular form, as shown in the worked example, which gives the calculation of area for the section shown in Fig. 22. It will be noted that the

CALCULATION OF AREA OF A HALF-SECTION By Simpson's Rule

Ordinate No.	Length.	Multipliers.	Functions of Areas.
1	4.18	1	4.18
2	4.07	4	16.28
3	3.83	2	7.66
4	3.58	4	14.32
5	3.20	2	6.40
6	2.77	4	11.08
7	2.12	2	4.24
8	1.26	4	5.04
9	0.00	1	0.00

$$\text{Multiplied by D} = 69.20$$

$$13.840$$

$$\text{Half-section Area} = 4.613$$

ordinates are very close together in this worked example, but the section is very shallow and the curve changes rapidly in consequence. In a deeper section a wider spacing might be used.

THE TRAPEZOIDAL RULE

This rule may be used with any number of ordinates, even or odd, whereas Simpson's Rule can only be used with an odd number. To apply the rule, add together all the ordinates and subtract half of the sum of the first and last ones. The result is multiplied by the common interval, which was described above as D.

The formula is illustrated by the example shown, which also shows the calculation of the area of the section shown in Fig. 22. It will be noticed that, as the curved side runs into the base line at the lowest point of the section, the ordinate there is represented by zero.

CALCULATION OF AREA OF A HALF-SECTION By Trapezoidal Rule

Ordinate No.	Length.	Multipliers.	Functions of Areas.
1	4.18	0.5	2.09
2	4.07	1	4.07
3	3.83	1	3.83
4	3.58	1	3.58
5	3.20	1	3.20
6	2.77	1	2.77
7	2.12	1	2.12
8	1.26	1	1.26
9	0.00	0.5	0.00

$$\text{Multiplied by D} = 22.92$$

$$\text{Half-section Area} = 4.584$$

$$\text{Actual Area by Planimeter} = 4.61$$

It will, therefore, be seen that the area as measured by Simpson's Rule is practically correct, whilst the error by Trapezoidal Rule is about $\frac{1}{2}$ per cent. This error is so small that it can safely be ignored, and, as the Trapezoidal Rule is easier and more convenient than Simpson's Rule, the use of it can safely be recommended to the young designer.

Mention is made above of the planimeter, and the following explanation of its use is therefore included.

THE PLANIMETER

There is also a method of arriving at the area of any figure by the use of an ingenious instrument known as the planimeter without doing any calculation whatever, except multiplying or dividing, as requisite in order to bring the result to the required scale. This latter method is the one that is always employed by professional naval architects, as it is even more accurate than calculation and saves a great deal of time. The drawback from the amateur designer's point of view is the cost of the instrument, which is in the region of £5, though a good second-hand one can often be picked up for about half this figure.

In appearance the planimeter is somewhat like a pair of compasses with one leg longer than the other. The long leg is the stationary leg and the short leg the movable one. As the short leg moves, a roller bears on the paper and actuates the dials. The dials are situated close to the hinge between the legs, and constitute the index on which the readings are shown.

The method of employing the planimeter is to place the fixed point on the paper in such position that the pointer on the movable leg can traverse the periphery of the area to be measured. The index must be set at zero before starting, whilst the pointer on the moving leg is at a predetermined starting point, such as the intersection of the centreline and load waterline. The outline of the figure is now followed round with the pointer in a clockwise direction. When the starting point is again reached, the index is read. In order to be additionally sure, after reading the index, the instrument can be run round the figure again in an anti-clockwise direction, when the index should return to zero.

* * * *

It will be noticed that though the keel has been shown in the sections examined, it was not included in our calculation of area. The reason of this is that for present purposes the keel is regarded as an appendage to the canoe body of the hull proper.

We will now assume that we are proceeding with our 36-in. design and have decided to use a section similar to Fig. 21. We accordingly draw this to the required size. We then have a section (or rather a half-section as only one side of the boat is shown in a design) on a L.W.L. beam of 8.6 in. and a body depth of 3 in., and by measurement we ascertain that the half-section area is 8.32 sq. in. = 16.64 sq. in. for the whole section.

The next point to consider is the relation of the area of the midship section to the displacement of the whole hull. For this purpose we can make use of the Co-efficients of Fineness. The further uses of these will be explained later, but for the moment we will consider

them solely as a means to estimate the displacement of a boat from the area of her midship section.

There are three Co-efficients of Fineness—the Midsection Co-efficient, the Block Co-efficient and the Prismatic Co-efficient.

The Midsection Co-efficient is the comparison of the actual section area with a rectangle, the width of the L.W.L. beam and the height of the body depth. As the beam is 8.6 in. and the body depth 3 in., the area of the rectangle is $8.6 \times 3 = 25.8$ sq. in. The section area of 16.64 sq. in. is 64.1 per cent. of this, so the Midsection Co-efficient is 0.64.

In calculating the Block Co-efficient the displacement of the hull in cubic inches is compared with that of a solid block having a length equal to the L.W.L. length, a breadth equal to the L.W.L. beam and a depth equal to the greatest body depth. In the present model the block would be $28 \times 8.6 \times 3 = 722.4$ cu. in. As we shall ascertain later, the displacement of the 36-in. boat, used as an illustration of the processes of designing, works out at 242.76 cu. in., and as this equals 33.6 per cent. of the block, the Block Co-efficient is 0.34.

The Prismatic Co-efficient is the ratio that the actual displacement bears to the volume of a solid block equal in length to the L.W.L., and having a transverse sectional area and form equal to that of the immersed midsection of the yacht. The block in this case would be 28 in. long, with a cross-sectional area of 16.64 sq. in., giving it a volume of 465.92 cu. in. The hull displacement is 242.76 cu. in., which is 54.2 per cent. of this, and the Prismatic Co-efficient is, therefore, 0.54.

The formula for ascertaining the approximate displacement of a hull from its immersed midsection area is:—

$$\begin{aligned} &\text{Midsection Area} \times \text{L.W.L.} \times \text{Prism. Co-eff.} \\ &= \text{Displacement in cubic inches, or, alternatively to get the Displacement in pounds avoirdupois:} \\ &\text{Midsection Area} \times \text{L.W.L.} \times \text{Prism. Co-eff.} \\ &\div 27.65 = \text{Weight.} \end{aligned}$$

Before seeing how this works out for our present boat, it should be mentioned that the

value taken for the Prismatic Co-efficient is one ascertained to be an average by experience from previous boats, and as an average figure 0.54 will be found satisfactory. It will be noticed that the divisor 27.65 is taken, this being the figure for fresh water. If we were designing to a rule which embodied sea water measurement the divisor would be 27.

For our boat the calculation will, therefore, be:—

$$16.64 \times 0.54 \times 28 \div 27.65 = \text{approx. } 9 \text{ lb.}$$

This, of course, has only given us the displacement of the canoe body, and for the total

right angles to the centreline of the boat, but, as a matter of fact, in modern designing it is found that the approved form of distribution of displacement can be more easily obtained when upright and maintained when heeled, if the lines are developed about what is termed a "raking midship section."

Now, the rake in the mid-section is brought about by the fact that the greatest body depth (G.B.D.) and greatest beam are not in the same fore-and-aft position. It is usual to speak of the position of these two points in percentages of the length of the L.W.L. measured from the fore end. Thus, for instance, the G.B.D.



FIG. 23 (a).
RAKING MIDSHIPS SECTION IN PLAN (SEE TEXT).

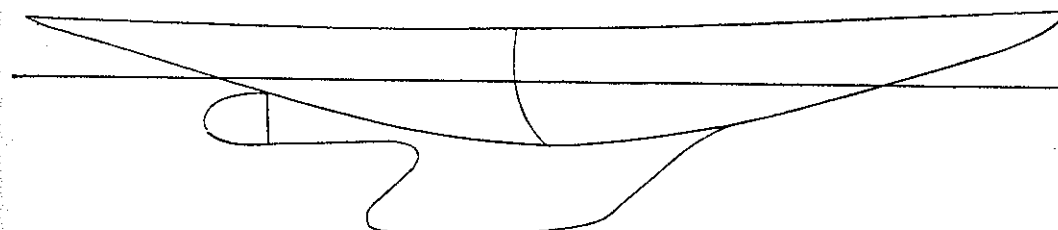


FIG. 23 (b).

displacement due allowance must be made for the displacement of the keel appendage to the hull proper. In the case of an A-class model, an allowance of between 6½ and 8½ lb. must be made. This, however, varies according to the type and length of the keel, and in a little boat of this kind the keel will displace from 1 lb. to 1½ lb., so from the midsection we have drawn we ought to get a displacement in the region of 10 lb.

An alternative use of this formula would be to work back from the required displacement to ascertain what area the midship section should have to ensure this displacement.

So far the reader has only been introduced to the ordinary transverse mid-section at

might come at the exact centre of the L.W.L. and its position would be spoken of as 0.50 of the L.W.L.

The amount of rake given to the mid-section is governed by the fore-and-aft balance of the diagonals, which will be investigated in due course. For the purposes of explaining exactly what a raking mid-section is, however, it may be assumed that the greatest beam will fall further aft than the G.B.D. Therefore, in order that the section lines can be worked out in such a way that the greatest depth merges harmoniously into the greatest breadth, the mid-section is so arranged that it will embrace both these points. Obviously, in order that this merging may be properly effected, the

section must be at such an angle to the centreline that the greatest breadth of each waterline will fall on this mid-section, also the greatest depth of every buttock and the greatest width of every diagonal. It is very important to know the fore-and-aft position of each of these points, and the rake of the section will determine this.

From the above it will be seen that there are two ways in which a boat can be designed about a mid-section. The mid-section can be the actual shape that will be used for the transverse mould (set at right angles to the centreline) on which the boat is planked up.

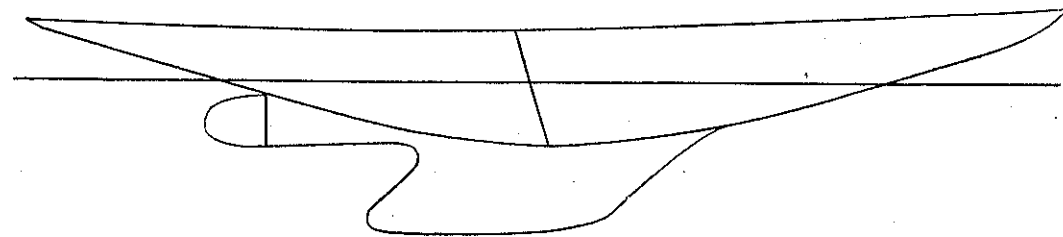


FIG. 24 (a).
RAKING MIDSHIPS SECTION IN ELEVATION (SEE TEXT)



FIG. 24 (b).

In other words, the mid-section used in designing can be the actual one that appears on the finished drawing of the vessel, and in that case the greatest beam may be astern of it or possibly the G.B.D. may be ahead of it, and the greatest waterline beams, greatest buttock depths and greatest diagonal widths need not coincide with it. Alternatively it may be a section which only appears on the drawings during the working-out of the lines and has no actual being as a mould in building.

The designer will be well advised to follow this latter method and use a raking mid-section, as not only will it help him to secure the best distribution of displacement, but will also materially assist him, as it fixes his greatest

breadths and depths, and thus materially assists in the designing of a fair and slightly hull.

Returning to the consideration of the raking midship section, there are two ways in which this might be raked. If the section is considered in the half-model as being set upright at right angles to the centreline (which in this plan forms the profile of the yacht), it could be swung backward in the fashion of a door opening until the outer point representing the greatest beam point arrived at the correct fore-and-aft position, whilst the G.B.D. remained correctly in position all the time.

This would be shown in the waterline plan as in Fig. 23 (a), where the G.B.D. and greatest beam point are joined by a straight line.

On the other hand, if the section is once more considered in an upright position at right angles to the centreline, keeping the bottom in position on the G.B.D. and the whole at right angles to the profile, the top is inclined sternward until the greatest beam point comes into its correct fore-and-aft position. The section will then be raked in an up-and-down fashion instead of transversely across the boat. This is shown on the sheer plan in Fig. 24 (a).

Now, if the section is raked by the first of these methods, it is plain that the greatest

depths of the buttocks will be moved sharply aft, but the greatest waterline widths on the topsides will be kept more or less close together vertically. The effect of this in elevation is shown on the sheer plan in Fig. 23 (b).

On the other hand, if the section is raked in an up-and-down fashion, the greatest depths of the buttock lines will be moved aft to a less degree, and the run of the vessel will be kept longer than under the first method, but, on the other hand, the greatest widths of the waterlines in the topsides will move aft very slowly in proportion to the greatest beam point, and unless the topsides have a large amount of flare, an unsightly wall-sided craft may result unless a certain amount of adjustment is made. The effect of this is shown in plan in Fig. 24 (b).

The first method by which the G.B.D. and greatest beam are joined by a straight line on the waterline plan is, therefore, recommended and will be used for designing the little boat which is being used as an example. This section may be considered as the "dominating section."

There is yet another method by which the raking mid-section is drawn as a curve on the waterline plan. It is, however, considered advisable not to introduce the beginner to too many complications and therefore this straight-line method will be used.

Now, having decided upon the mid-section of the boat and that it shall be a raking mid-section, the next step is to place it. In the present instance the G.B.D. has been placed at the exact centre of the L.W.L. It is by no means certain that this is correct, and some designers hold that it should be forward of this point. As a matter of fact, this position was used by Mr. W. J. Daniels for placing the G.B.D. of a number of successful boats, including "Crusader" and "Albion." On the other hand, a position slightly forward of amidships was used for "Glengarry" and the Olympic Model Yachting Regatta champion "Fusilier."

The designer can now proceed to draw a tentative profile of the canoe body of the boat. To do this, three points have already been

determined—the forward and after endings of the L.W.L. and the position of the G.B.D. A line representing the L.W.L. can now be drawn and these three points spotted in. The length of the boat has to be 36 in., and the L.W.L. is fixed at 28 in. There is, therefore, 8 in. to be divided between the forward and after overhangs. In order that a boat may look balanced, her overhangs should be the same length or nearly so. It was accordingly decided to give 4 in. overhang at each end.

It will be found convenient and assist in drawing the lines if the section lines and waterlines are struck on the sheer plan before attempting to draw the profile. On a larger boat it is usual to divide the waterline into ten equal parts, but in this little craft eight will be found sufficient. The sections will accordingly be spaced $3\frac{1}{2}$ in. apart. The waterlines also are represented by straight lines in the sheer plan, and the most convenient spacings are $\frac{3}{4}$ in. or 1 in. In the present instance the waterlines have been spaced 1 in. apart. Before proceeding, it must again be emphasised that the straight lines that form the basis of the design are almost more important than the lines themselves. Every straight line *must* be dead true, and every right angle must be exact.

The necessary instruments for drawing have been already mentioned, and there is no need for the list to be repeated here. Taking the long batten, bend it gently until it passes through the G.B.D. and L.W.L. endings. It must not be forced in any way, but allowed to take its natural curve. This will ensure the curve round the G.B.D. being easy and not too sharp. The ends beyond the L.W.L. endings forming the overhangs can carry out the same curve. It is the object of every designer to get the ends of his boats low in order to gain as much length as possible when the yacht is sailing, and, if necessary, the ends can be eased down a little afterwards. This should not be done to such an extent, however, that the ends look dragged down or drawn out, but rather they must be kept so that the yacht is a harmonious and compact whole. Many

yachts have their profiles dragged out to such an extent that they never use a great portion of the overhangs. This is a mistake, as it represents unnecessary windage and weight, and renders a boat not only unsightly, but a bad sea boat. The craft under design is, however, limited to 36 in. L.O.A., and the question of dragging the ends out does not arise.

Turning back to the body plan on which our mid-section has been drawn, strike in the main diagonal (otherwise called the bilge diagonal). The angle at which this is struck on the body plan is determined by the point where the mid-section turns from the topsides into the floor of the boat, and it should follow through similar points on the other sections. Thus in a shallow-bodied boat the bilge diagonal can be carried out at a low angle that will keep the turn of the bilge low in the boat, and the overhangs will consequently be kept very low. In a deeper-bodied boat, such as we are at present designing, the angle of the bilge diagonal will be considerably steeper. It must always be borne in mind that if the boat is to be without disturbing influences at varying angles of heel, the overhangs must be a correct blend with the middle of the boat.

The correct method of obtaining the angle for this main diagonal on the body plan is to draw a tangent to the periphery of the mid-section at the exact point where the topsides merge into the floor. On this tangent a perpendicular is erected at the point of contact with the section and produced until it meets the centreline. This diagonal must be repeated on the body plan on the other side of the centreline.

This diagonal gives another spot which guides the designer in drawing the profile of the after overhang of the boat. The after end of the boat's profile should be continued beyond the boat until it comes to the height at which the diagonal meets the centreline on the body plan. The point where the profile reaches the height of the diagonal forward is subject to adjustment, and it cannot yet be determined. Before leaving the profile, the

curve should be checked to see that it is even on each side of the G.B.D. As the G.B.D. is at the exact centre of the L.W.L., this means that the sections immediately fore and aft of it will be equidistant from it and the next sections likewise. The depth at each section should be checked accordingly, and any necessary adjustment made. During the drawing of all curves, the batten will, of course, be kept in place with weights.

The next line to draw is the deckline, or, in the case of a boat with a tumble home, the greatest beamline. The expression "tumble home" implies that the width on deck is less than on one of the lower waterlines, and the section consequently tumbles home on itself. When there is no tumble home, the deckline is, of course, identical with the greatest beamline.

In order to draw the deckline, a baseline, representing the centreline of the yacht, is first drawn. The plan which is now being started is what is known as the "waterline plan." This was explained in an earlier chapter. Before proceeding with the deckline, the section lines should be put in to correspond with those on the sheer plan. As explained, the sections which, in the body plan, appear as curves, appear in the sheer plan and waterline plan as straight lines. The buttock lines can also be put in. The latter are spaced 1 in. apart. Great care must be taken to get these lines exact, as the accuracy of the whole plan depends on them.

It will facilitate drawing the greatest beamline if a straight line is drawn parallel to the centreline at a distance from it equal to the greatest beam. The greatest beam of this boat has been fixed at 9 in., and this line will therefore be 4.5 in. from the centreline.

The transom will appear in the waterline plan as a straight line, but as eventually our transom will be raked, this really represents the upper edge of it. The transom is, however, always considered in the first instance as being vertical, and is trimmed off as requisite when finishing the design. The width of the transom must next be considered. In deciding the width for the transom

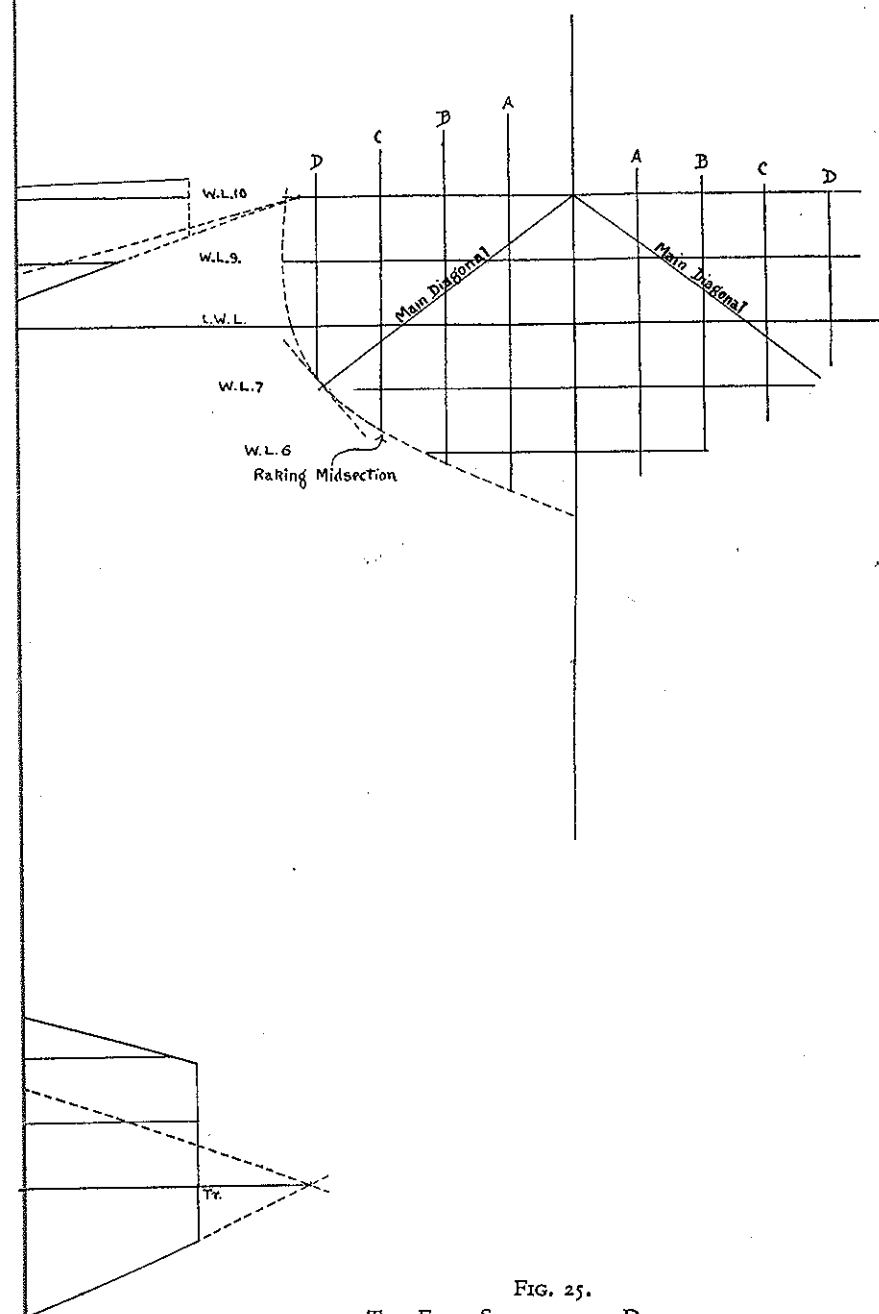


FIG. 25.
THE FIRST STEPS OF THE DESIGN.

[To face page 42.]

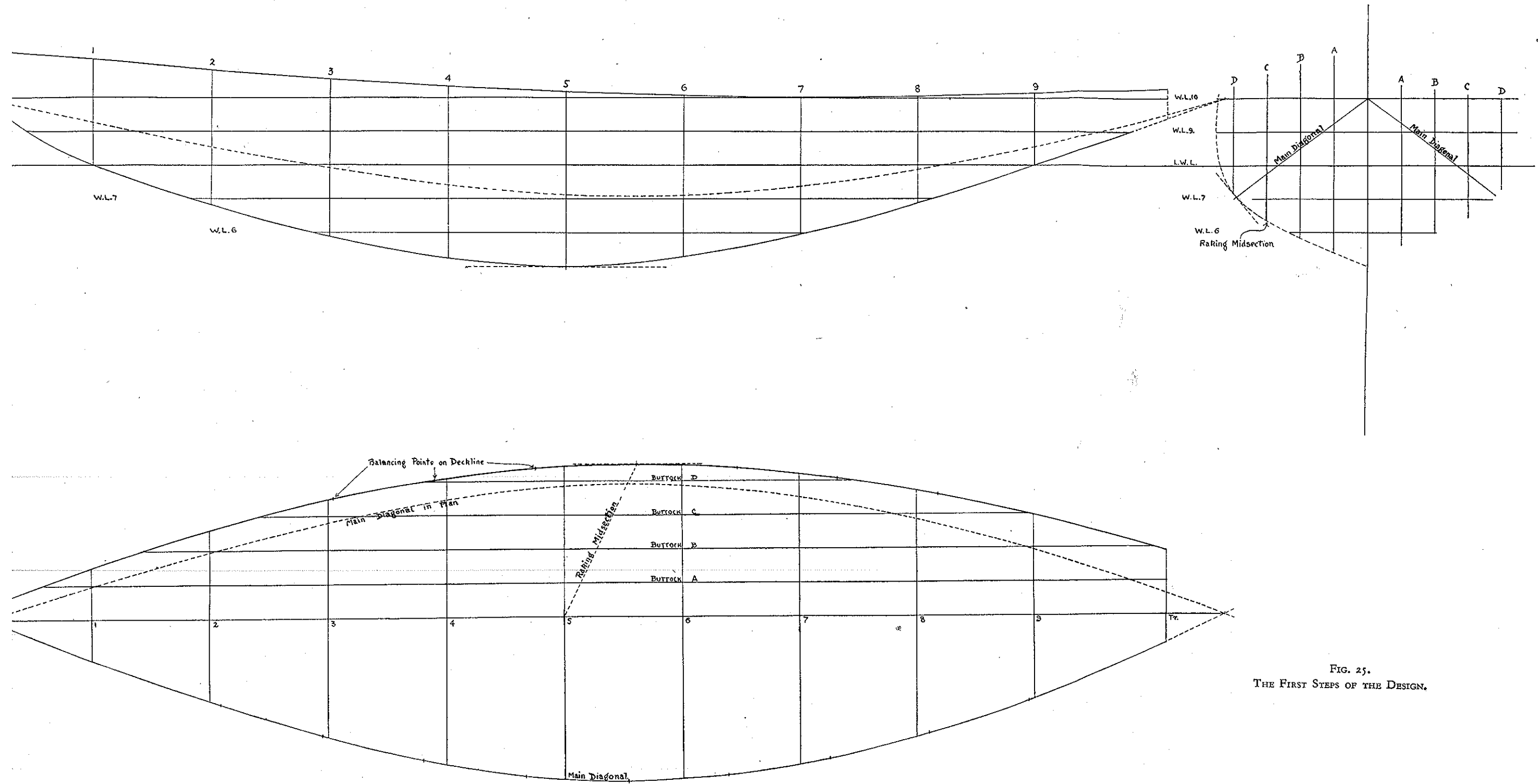


FIG. 25.
THE FIRST STEPS OF THE DESIGN.

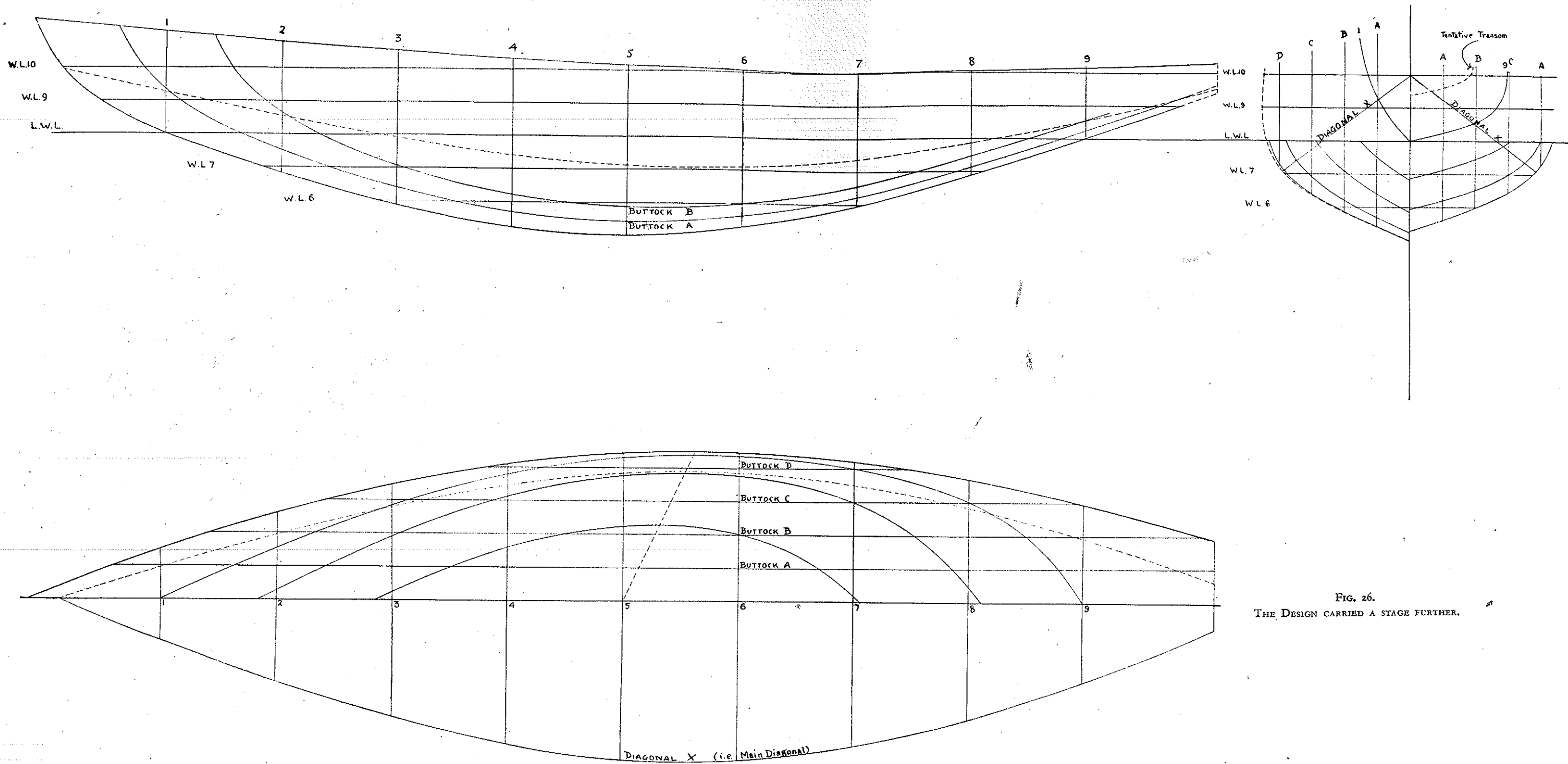


FIG. 26.
THE DESIGN CARRIED A STAGE FURTHER.

the raked mid-section: On the centreline find the position of the G.B.D., which was fixed at the exact centre of the L.W.L. This is then joined to the position of the greatest beam.

Turning to the body plan, measure out from the centreline horizontally to the position where the main diagonal intersects the mid-section, this being the widest point of the diagonal. This point is found to be 3.91 in. from the centreline, and the position at which our raking mid-section is 3.91 in. wide is 1.87 in. abaft the G.B.D., and this position can now be marked on the waterline plan as being the fore-and-aft position of the greatest width of the main diagonal. Immediately opposite this, on the other side of the centreline, set out the greatest width of the main diagonal measured in its own plane. This is obtained by measuring from the centreline on the body plan down the diagonal to its greatest point. A simple method of transferring these various measurements is by using a strip of paper.

From the sheer plan we can find the spot at which the after end of the diagonal produced would meet the profile produced. This is another way of saying where it would meet the centreline. This position must also be spotted in on the centreline on the plan, where we are now drawing the diagonal to its own plane.

Measure from this point to the fore-and-aft position of the greatest width of the diagonal and set out a similar distance forward. This will give us three points—a forward ending and an after ending, also the position of greatest height which is exactly midway between them. The long batten is used to draw this curve and is gently bent into position, not being forced in any way, but allowed to take a natural curve. It is held in position with the weights and the line drawn in. This line must be checked up and carefully balanced on either side of the greatest width, as was done with the deckline.

The next step is to draw the bilge curve in plan upon the waterline plan and in elevation upon the sheer plan. It will be seen that on the body plan the main diagonal cuts both waterlines and buttock lines diagonally. Whilst this gives the breadths and heights of these

points of intersection, it does not give their fore-and-aft position.

Starting with the L.W.L., measure the distance along the diagonal from the centreline to the point where the diagonal and L.W.L. intersect. The position forward where the diagonal is this width will immediately give the fore-and-aft position of the forward intersection of the L.W.L. and the diagonal. Similarly the after point can be found. Transfer these positions to the elevation and also to the waterline plan. In the case of the waterline plan, at the correct fore-and-aft position it will be necessary to set off the actual width out from the centreline of the point of intersection, remembering that we are now drawing the diagonal in plan *not* in its own plane. The distance has now to be measured on the section plan along the L.W.L. to the point of intersection with the diagonal. This gives the breadth of the L.W.L. at the point it intersects the diagonal, and, as we have already found the fore-and-aft positions, these two spots can be marked on the waterline plan.

In a similar manner, the intersections with the buttock lines can be measured and set out on the plan of the diagonal in its own plane, thus finding the positions at which the buttocks intersect the diagonal. These positions can be transferred straight away to the straight lines representing the buttocks in the waterline plan, and by measuring the distance above or below the L.W.L., the correct positions can be found and marked on the sheer plan.

When all these positions have been marked, the diagonal can be drawn through the spots. The curves should fair exactly, and if there is any discrepancy, it will be necessary to check one plan with another and make the necessary corrections. It should be emphasised at this point that all intersections between the various lines in the different plans must absolutely coincide. For example, the main diagonal must cross the L.W.L. in exactly the same fore-and-aft position on the sheer plan and waterline plan, and so on.

The forward profile of the boat can now be finally adjusted and completed, as it must pass through the point of the forward ending of the

bilge diagonal, which has already been drawn in elevation on the sheer plan.

Before proceeding further with the development of the body of the boat, the sheerline should be drawn in. Its curvature will be largely determined by the amount of freeboard that is decided on. The midship height has been determined by the midship section, and this point should be put in first. The height at the stern and the character of the curve of the sheerline is very largely governed by the type of boat that is being designed. Sufficient freeboard is necessary to keep the boat dry, and a bold upstanding sheer forward is a characteristic of many craft that are intended to keep the seas in heavy weather. Apart from any restrictions on freeboards which form part of various measurement rules, there are only two considerations that need govern the designer. The first of these is the purely utilitarian consideration of keeping the deck dry, and the second is the æsthetic consideration of appearance. A badly planned ugly sheerline does more to mar the appearance of a craft than anything else. Study should, therefore, be given to the sheerline of boats that have a beautiful appearance on the water, and the designer should endeavour to get an equally desirable line.

Having completed the midship section, the deckline, profile and main diagonal of the boat, the design of the canoe body becomes practically a matter of routine. These lines in themselves entirely govern the design, and if they have been properly planned provided the remainder of the design is carried

out in such fashion that she is geometrically correct, the whole design will follow. The design carried out to this point is shown in Fig. 25.

Before leaving the subject of these governing lines, a word or two should be written about the actual turn of the stem. This turn should be strictly in keeping with the character of the midship section. Thus a boat with a hard bilge should have a hard turn where the stem turns upward. Conversely, a boat with a slack bilge requires a long gentle turn. Moreover, the rake of the transom must match the forward profile if the boat is to look balanced and sightly. A boat with a hard turn to the stem needs her transom more upright than one with a longer nose.

Yacht designing is both a science and an art. There are boats that sail well and yet have their appearance entirely ruined by an ugly sheer. There are other boats that look pretty on the water and are complete failures through lack of balance. A sailing craft under way is one of the loveliest things ever devised by man. The great designers have all been artists as well as men of science. Appearance above water alone will not win races, but it is something worth striving for, so that our little yachts in their modest way may be things of beauty and a joy to the eye.

The embryo designer should, therefore, cultivate his eye. He should try to visualise craft from the drawings, learn to distinguish those points that make for beauty of line, and he will gradually come to the conclusion that beauty and harmony are synonymous.

CHAPTER V.

Completion of the Canoe Body. Curves of Areas. The Colin Archer Theory. Calculation of Displacement and Centre of Buoyancy. Speed Factors. Tumble home.

AFTER the outline of the hull design has been completed as detailed in our last chapter, it only remains to complete the lines. The work of the designer in this connection may really be considered as drawing within the length of boat at his disposal a series of sections that carry out the characteristics of the midship section that has been decided upon. The manner in which the main diagonal has been plotted has already assured the design being fair throughout the bilge, and the waterlines and buttocks have now to be developed in a manner that will ensure the same result in respect of the underbody and topsides.

The first line to receive attention must be the L.W.L. We have already five points on this. The forward and after endings are known, also the positions forward and aft where it crosses the main diagonal and the point on the raking midsection where it reaches its greatest breadth. These points are sufficient to draw the entire L.W.L. with the exception of the part lying between its after intersection with the main diagonal and the after L.W.L. ending.

In order to get the curve of this part of the L.W.L. correct, the points of intersection with the two inner buttocks are needed, and to get these two points, part of the buttocks will have to be drawn in tentatively on the sheer plan. The positions at which the main diagonal crosses these buttocks can be found in a fore-and-aft direction from the waterline plan and the heights can be taken from the body plan. With this data these positions can be marked on to the sheer plan, and one point has now been definitely fixed on each of these two buttocks.

Now it is obvious that if the character of the sections is to be maintained throughout the after-body, the inner buttock lines must be practically parallel to the profile for some

distance above and below the L.W.L. These lines are accordingly drawn tentatively through the positions that have been found, and this gives the two further points that are required to draw the after end of the L.W.L. It must not, however, be overlooked that since this waterline ending is based on two points that have not been finally and definitely determined, it must be regarded as being a tentative line also. A tentative transom is now drawn. The transom ending of the boat is first treated as if it was going to be an upright one, situated at the extreme end of the deckline. When the after end of the boat has been completed, the transom is trimmed off to suit the profile and deckline of the yacht. The height of the top of the transom is known and its breadth on deck, also the lowest point which falls on the profile. The point of its intersection with the main diagonal is also known. The latter point can be ascertained by measuring the height in the sheer plan, the beam in the waterline plan or the distance down the diagonal itself from the centreline taken from the drawing of the diagonal in its own plane. Whichever of these is taken, the point found must be the same, provided the diagonal has been correctly drawn in the various plans. A tentative transom can now be drawn through these three points, preserving as far as possible the general characteristics of the midsection.

Tentative sections can also be drawn at the forward and after L.W.L. endings. For the forward section, we have the lowest point, the deckline and its intersection with the main diagonal, and on the after one we have also the points of intersection with the two inner buttocks, as drawn in tentatively.

After this the inner buttock must be drawn in. It should be observed that the profile is in reality a buttock line taken through the centre of the ship, and if the technique of draughtsmanship is correctly observed, the

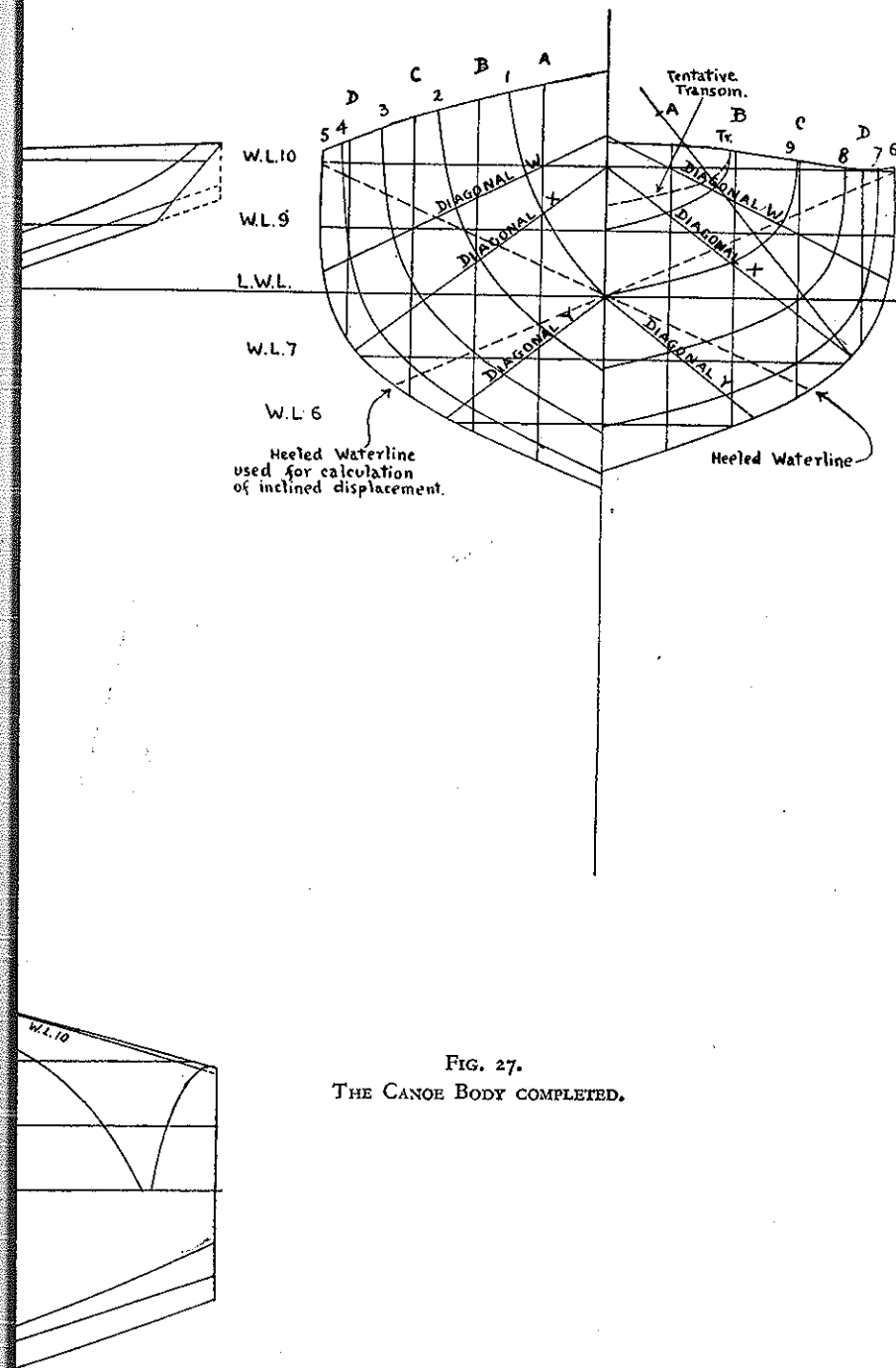


FIG. 27.
THE CANOE BODY COMPLETED.

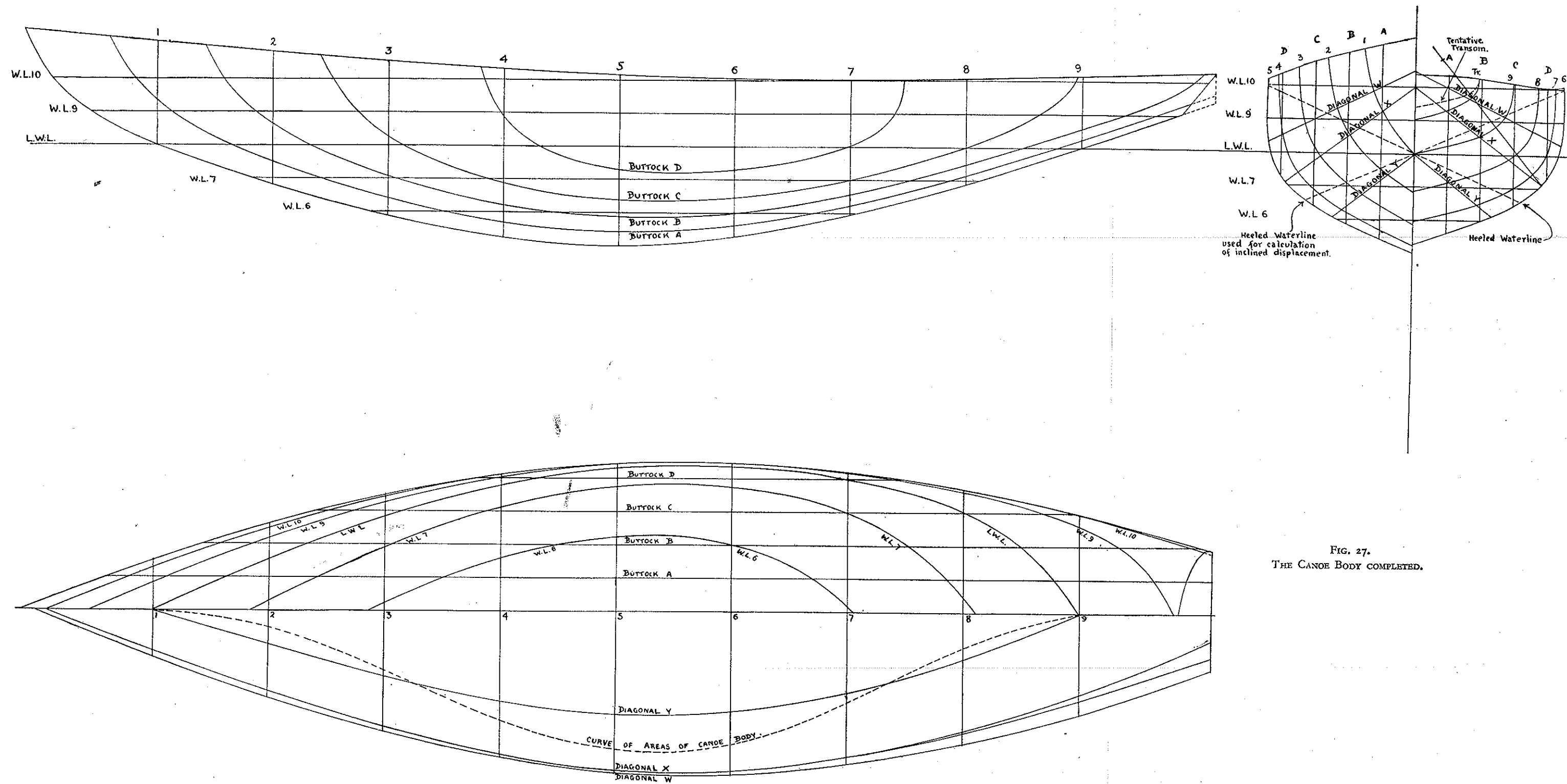


FIG. 27.
THE CANOE BODY COMPLETED.

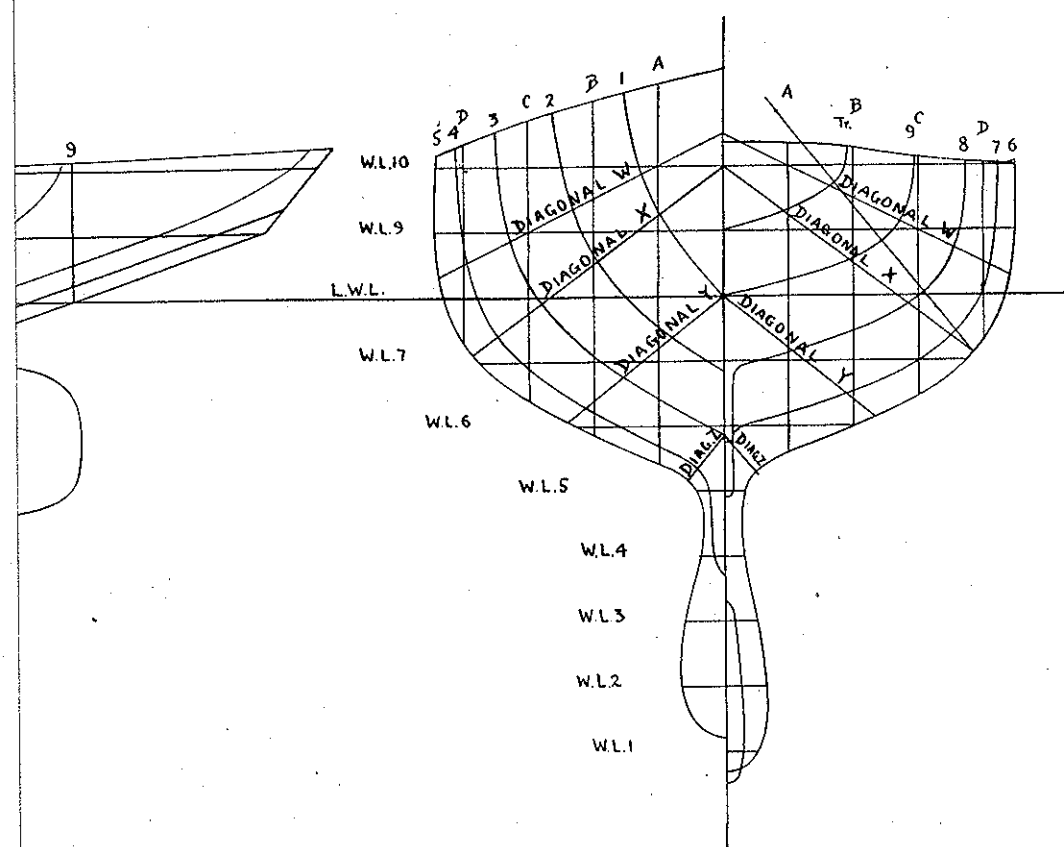
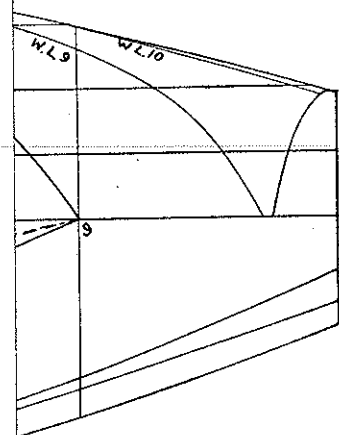


FIG 28.

The design of the hull completed.

Scale: one-third of full-size.

Note. It will be observed that certain lines used in working out the design are omitted from the final drawing.



[To face page 47.]

COMPLETING THE CANOE BODY

buttock lines of the topsides will be consistent in character. In drawing lines such as this buttock, it will possibly be of assistance to the novice to observe the following procedure, which is almost identical to that recommended in drawing in the deckline. The buttock has to attain its greatest depth at a given position on the raking midsection. Through the lowest point, as plotted on the sheer plan, lightly pencil a horizontal line. If the curve of the buttock is correctly drawn through this lowest point, the line must be a tangent to it. Aft of the lowest point the inner buttock runs practically parallel to the profile line for its full length. Forward it gradually comes away from the profile, but the character of the curve is the same, and the turn-up to the deckline follows the stem.

The second buttock line is drawn in a similar manner, and then the first waterline below the L.W.L. can be developed. Starting from the forward end, we know its ending, where it crosses the two inner buttocks and the point on the raking midsection where it comes to its greatest width. If any difficulty is experienced in getting the waterline through the points of intersection with the buttocks, the necessary adjustment must be made to the buttock lines until one plan fairs with the other perfectly. In a similar way the waterline is continued aft and similar adjustments are made as requisite.

In a like fashion the lowest waterline of the hull is developed. This gives us the complete underwater body of the yacht, as if fair curves have been drawn and the points of intersection tally in the sheer and waterline plans, the sections should fair without any further adjustment of any kind. The design developed to this point is shown in Fig. 26.

Before proceeding with the topsides, the third buttock line should be put in. This will form a further check on the underwater body.

Proceeding with the topsides, the first waterline above the L.W.L. has next to be drawn. This will, of course, pass through its correct points at profile, diagonal and mid-section. In addition to these five fixed points, we have also points on the tentative sections

which have been drawn at the L.W.L. endings.

In order to guide us, we draw in a tentative section midway between the forward L.W.L. ending and the fore-and-aft position of the point of greatest body depth, which in this case is situated at the exact centre of the L.W.L. The underwater part of this section is already fixed by the waterlines and buttocks that have been finally settled, and we also know its width on deck. From this tentative section, the point of intersection with the waterline above the L.W.L. is obtained, and this point will be a guide to the character of the curve. When this has been faired up nicely with the forward sections, this in turn will give other points for completing the forward ends of the inner buttocks. As we have the points of their intersections with the main diagonal and the points on the sheer, no difficulty should now be experienced in getting all this part of the design nicely faired up. The intermediate sections have also to be drawn in. The outer buttock and upper waterline follow naturally. In the completion of the forward part of the boat, no difficulty should be experienced, as no further adjustment should be required, provided that the buttocks and waterlines have been correctly faired. In drawing these forward sections, the depths of each buttock and breadths of every waterline are spotted on the body plan and a curve swept through them. For this purpose a celluloid spline will be found very useful.

This completes the forward part of the canoe body of the yacht, and an exactly similar procedure should be followed in the development of the after-body.

In order to act as a further check upon the fairness of the hull, it is customary to take out further diagonals. These diagonals differ materially from the main diagonal, as they are obtained from sections that are already determined, whereas the main diagonal was a definite line laid down at the commencement of the design before any section other than the midsection had been drawn. The curves formed by these diagonals should, however, be similar in character to the main diagonal.

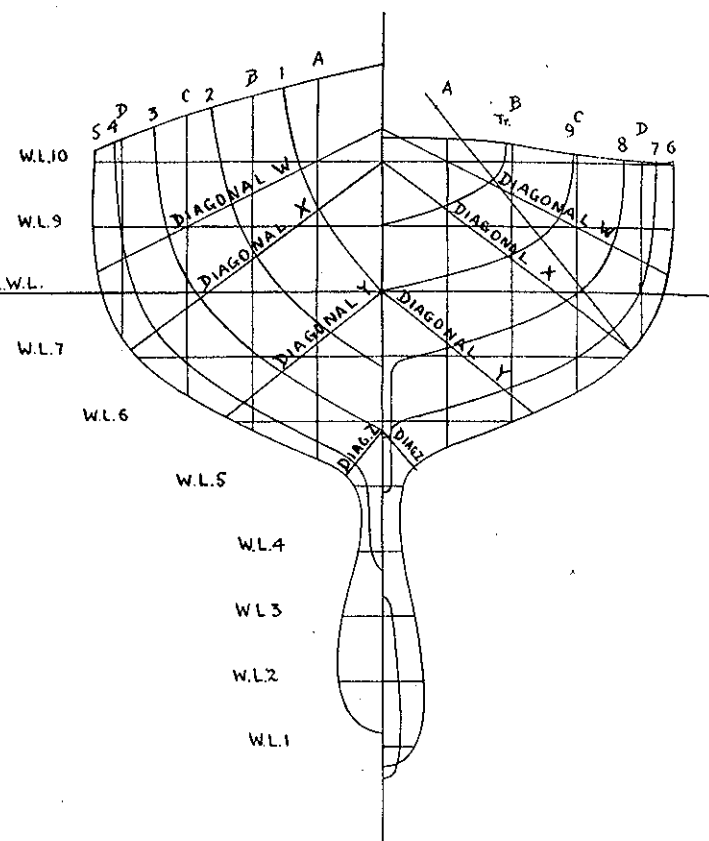
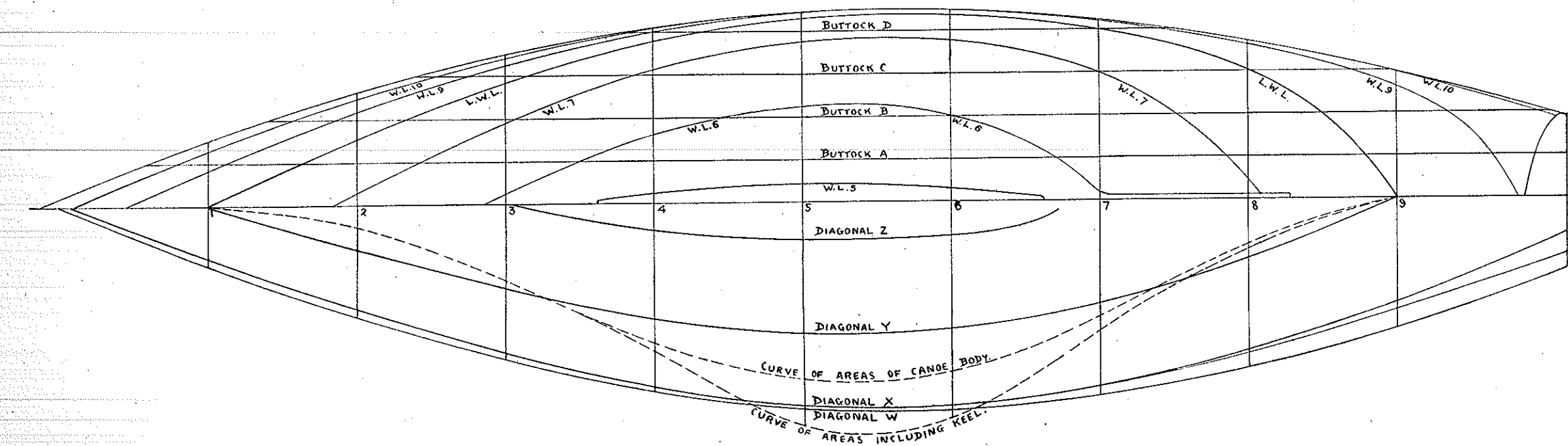
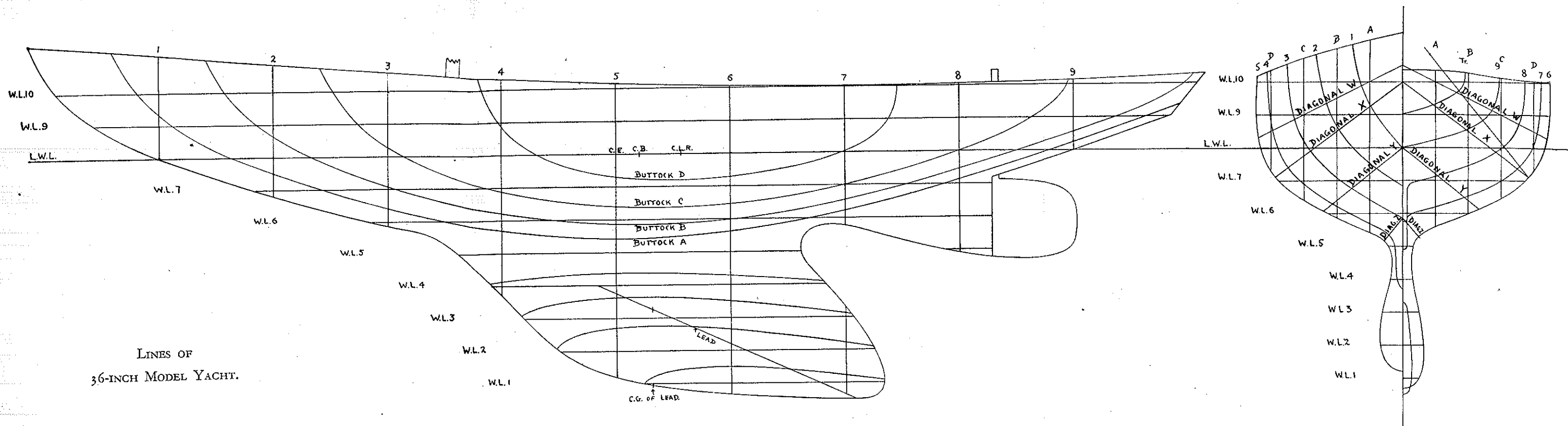


FIG 28.

The design of the hull completed.

Scale: one-third of full-size.

Note. It will be observed that certain lines used in working out the design are omitted from the final drawing.

These additional diagonals should be arranged above and below the main diagonal, so as to form a curve round the hull, which shall be as nearly as possible intermediate with the run of the waterlines and the buttock lines, or, in other words, at approximately 45 degrees. The line these diagonals make round the hull is very similar to the lay that the planking will have to take, and therefore they are a good test of the ease or difficulty that the boat will present in planking up.

A further diagonal can, with advantage, be taken out on the after part of the hull, following the turn of the bilge from the main diagonal position on the midsection up to the turn of the transom. This, when plotted in its own plane, will teach* into the primary main bilge diagonal curve on the midsection as shown.

This completes the draughtsmanship of the canoe body of the vessel, which is shown in Fig. 27. As the hull proper is now designed, it must next be proved. In order to do this, the Curve of Areas has to be drawn. In order to plot the Curve of Areas, the underwater areas of each of the transverse sections has to be calculated. The methods by which this can be done have already been explained. The usual method of plotting a Curve of Areas is to use the same baseline as has been used for the diagonals, that is, on the other side of the centreline on the waterline plan.

A convenient scale should be chosen to plot the section areas, and these should be marked out at right angles to the baseline on the respective section stations. The scale chosen in this particular instance is one-half of full size. A curve has to be drawn through these points to form the Curve of Areas. For this purpose a somewhat slender batten will have to be used. This curve should reach its highest point somewhere between the point of G.B.D. and the greatest beam point on the L.W.L. This is also shown on Fig. 27.

Now a number of theories have been propounded as to the virtues of certain specific forms of Displacement Curves (or Curves of Areas), and some authorities have gone so far as to lay down the axiom that the Curve of

* Teach = fair nicely into.

Areas should be one of the first lines drawn in the design and the form of the hull modelled to fit the desired curve.

The best known of these theories is the one propounded by the late Colin Archer, known as the "wave-form" theory. This requires that the Curve of Areas should be in the form of a waveline. To accord with this the Curve of Areas for the fore-body must be a curve of versed sines of a length of 60 per cent. of the L.W.L., and the after-body a trochoidal curve of the remaining 40 per cent.

Before passing to the discussion of this theory, it may be as well to give the method of construction for the curve of versed sines and trochoid.

In order to give the reader the opportunity of comparing the actual Curve of Areas of the little hull, which has just been designed with that prescribed by the Colin Archer theory, it can be assumed that it is desired to draw a Curve of Areas for our boat in this fashion. The fore-body will, therefore, be 60 per cent. of the waterline length, that is, 60 per cent. of 28 in., or 16.8 in., and the after-body 40 per cent., or 11.2 in. At this point (*i.e.*, the end of the fore-body) erect a perpendicular having a length of 4.16 in., to correspond with the area of our half midsection. This line will become the diameter of a circle which is known as the "Generating Circle."

Dealing first with the fore-body, which is to have a curve of versed sines drawn, call the mid-point A and the forward L.W.L. ending B. Divide the circumference of the forward semicircle into a number of equal parts at, say, *a*, *b*, *c*, and the baseline AB into an equal number of even parts at *a'*, *b'*, *c'*. Through *a*, *b*, *c*, draw lines parallel to the baseline AB and erect perpendiculars at *a'*, *b'*, *c'*. Through the points of intersection draw the curve B *c''* *b''* *a''* D. This is the curve of versed sines.

To describe the trochoid for the after-body, the circumference of the semicircle is similarly divided at *e*, *f*, *g*, and the baseline at *e'*, *f'*, *g'*. First join the points *e*, *f*, *g* to A. Then through these points *e*, *f*, *g*, draw lines parallel to the baseline. Through *e'* draw a line parallel to Ae, through *f'* draw a line parallel to Af, and

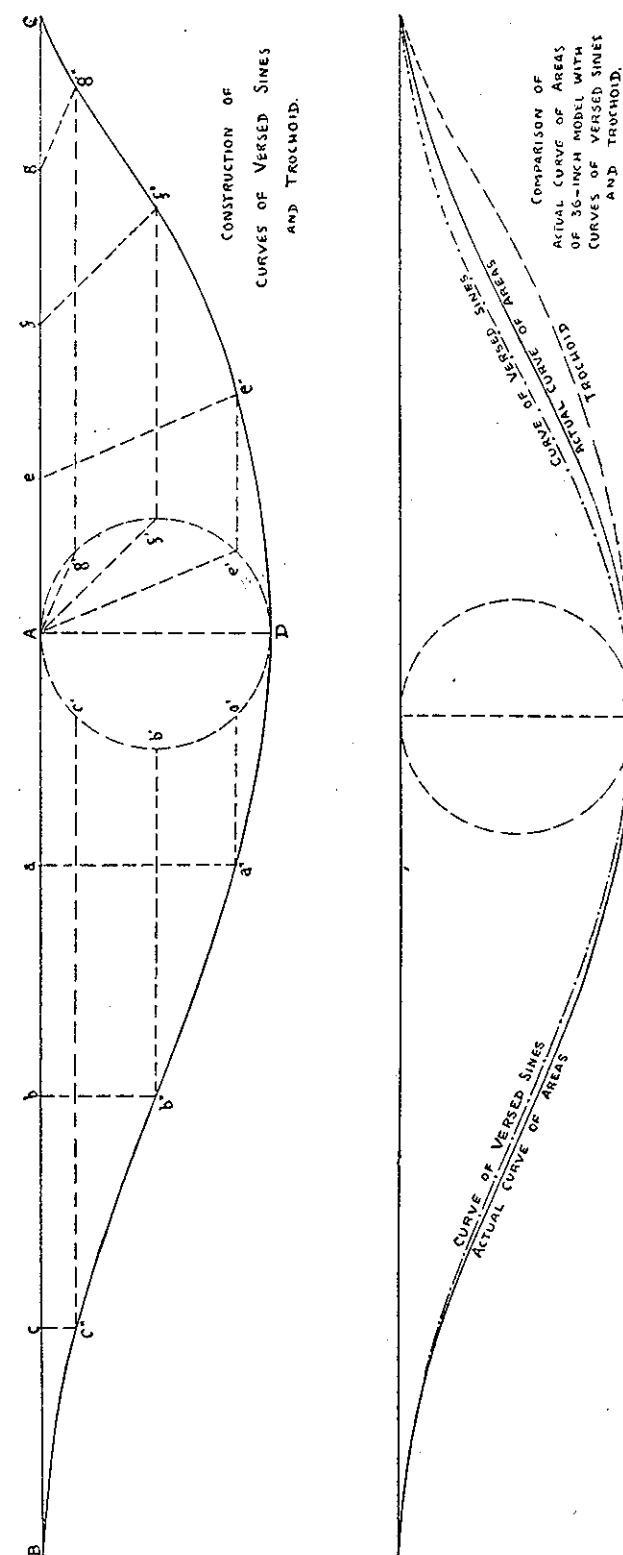


FIG. 29.

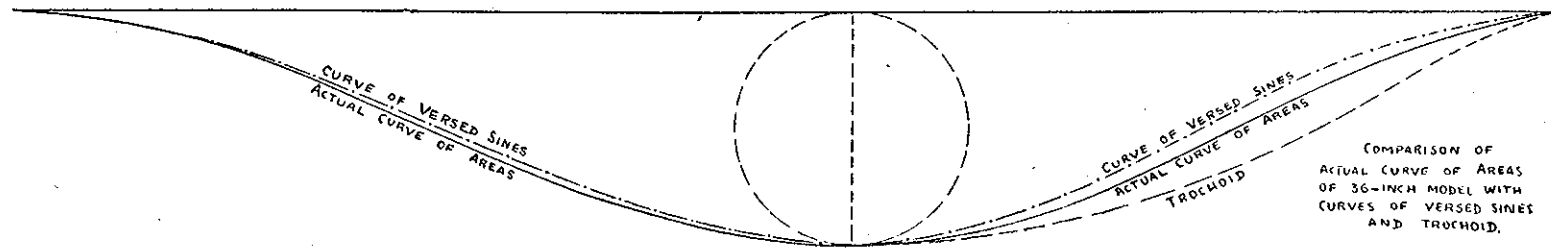
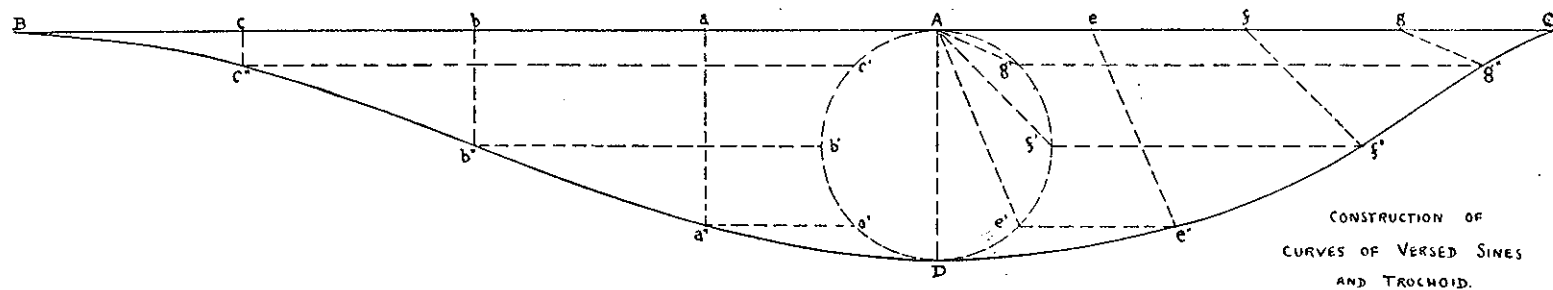


FIG. 29.

through g' draw a line parallel to Ag . Draw in the curve $Cg''f''e''D$, which is the required curve of the trochoid.

The method of drawing these two curves is shown in the upper diagram in Fig. 29. The curve shown in this is absolutely in accordance with the Colin Archer theory. As the Curve of Areas of our little 36-in. model has its highest point considerably more forward than the true Colin Archer Curve, the curve is redrawn in the lower diagram of Fig. 29 with the generating circle placed at the highest point of the actual curve. This gives the reader an opportunity of comparing the Curve of Areas with a curve of versed sines forward, and curves of versed sines and trochoid aft. It will be seen that the forward part closely approximates to the versed sines curve. The after part falls between the curves of versed sines and trochoid, but its nature partakes of the former.

The curve of versed sines is much used for Displacement Curves, but usually has its fine ending somewhat snubbed back. Although many writers place much faith in this wave-form theory, there is no doubt that many highly successful yachts have been built that do not in any way conform to it. Moreover, it must be remembered that the Curve of Areas only represents the form of a vessel when she is at rest, and actually, owing to the fact that she heels, this form is never present when she is sailing, except when immediately before the wind in a light breeze. In the considered opinion of the authors of this book, there is no specific value attached to any particular form of Displacement Curve. It is, however, essential that the curve shall be fair and harmonious, as this is evidence of a well-designed hull with an even rate of displacement governing the entry and delivery. It may be added that the method which has been employed which starts with a balanced main diagonal will practically ensure a distribution of displacement that will be as nearly as possible correct.

Although the Curve of Areas of the canoe body only is not used in actually proving the hull, it is of very great use to the designer in

estimating the type of hull he has drawn. The inferences to be drawn are largely a matter of practice, but as a guide it may be mentioned that the hull should show a nice gradual rate both in entry and delivery without any sudden changes.

It will also be of use if at this point we take out the displacement of the canoe body for comparison with our estimated displacement, and to check that our yacht has approximately the desired displacement. While we are doing this it is only a matter of a few more figures to ascertain the Centre of Buoyancy of the canoe body. This will be of use when designing our keel as it will give a rough idea for placing the bulk of the keel (or fin) displacement. In order to explain these calculations it will be better to take them separately.

It has been stated that a vessel floating in water displaces a volume of water equal to her own weight. If, therefore, the volume of the boat is calculated up to the L.W.L., it will give the volume of water displaced. As the weight of water is a known quantity, it is quite an easy calculation to ascertain the weight of the displaced water which is identical with the weight of the boat.

In the calculation of Displacement, either Simpson's Rule or the Trapezoidal Rule can be used, as was explained in the last chapter, when we were dealing with cross-sectional areas. The latter have already been plotted in the form of a Curve of Areas. On this the ordinates which represent these areas represent square inches. It only remains to calculate the volume of the Curve of Areas to have the volume of the underwater body of the boat in cubic inches. This gives us the Displacement in Cubic Inches, and if the Weight is required, all that is necessary is to divide the Displacement in Cubic Inches by the number of cubic inches of water that go to 1 lb. In the case of fresh water this is 27.65 cu. in. and 27 cu. in. of salt water.

It should be added that a Curve of Areas can be measured with a planimeter if desired, though this is usually calculated as the figures are required for calculation of the C.B.

Turning to the consideration of buoyancy

EXAMPLES OF CALCULATION TO FIND DISPLACEMENT AND CENTRE OF BUOYANCY

By Simpson's Rule

Section No.	Areas of Half Sections.	Simpson's Multipliers.	Functions of Areas	Arm.	Moments.
1	0.00	1	0.00	0	0.00
2	1.10	4	4.40	1	4.40
3	3.55	2	7.10	2	14.20
4	6.57	4	26.28	3	78.84
5	8.32	2	16.64	4	66.56
6	7.90	4	31.60	5	158.00
7	5.11	2	10.22	6	61.32
8	1.95	4	7.80	7	54.60
9	0.00	1	0.00	8	0.00
			104.04		437.92

Up to this point the figures used for the two calculations (Displacement and Centre of Buoyancy) are worked out by same methods, but in finding the Displacement only the Moments are not required, so that the Functions of Areas are not multiplied by the Arm.

Displacement

Sum of Functions of Areas	=	104.04
Multiplied by Spacing	=	3.5
		52020
		31212
Divided by		3)364.140
		121.38

Displacement in cubic inches :—

= 121.38 for Half Model,
or 242.76 for Model.

If yacht is to be calculated out for Fresh Water, divide number of cubic inches displacement by 27.65 to get weight in pounds. For Salt Water, divide by 27.

Displacement of vessel in fresh water :—

$242.76 \div 27.65 = 8.779$ lb.

Centre of Buoyancy

Sum of Moments is divided by Sum of Functions of Areas and result multiplied by Spacing.

$(437.92 \div 104.04) \times 3.5 = 4.209 \times 3.5 = 14.731$

Therefore C.B. of canoe body is 14.731 in. abaft Section No. 1.

By Trapezoidal Rule

Section No.	Areas of Half Sections.	Multipliers.	Functions of Areas.	Arm.	Moments.
1	0.00	0.5	0.00	0	0.00
2	1.10	1	1.10	1	1.10
3	3.55	1	3.55	2	7.10
4	6.57	1	6.57	3	19.71
5	8.32	1	8.32	4	33.28
6	7.90	1	7.90	5	39.50
7	5.11	1	5.11	6	30.66
8	1.95	1	1.95	7	13.65
9	0.00	0.5	0.00	8	0.00
			34.50		145.00

It will be noticed in above calculation that as areas of end sections (Nos. 1 and 9) are 0, the Functions of Areas are same as Half-Section Areas, and when this is so, some figures can be saved.

Displacement

Sum of Functions of Areas	=	34.50
Multiplied by Spacing	=	3.5
		17250
		10350
		120.750

Displacement in cubic inches :—

= 120.75 for Half Model.
241.5 for Model.

Displacement of vessel in fresh water :—

$241.5 \div 27.65 = 8.731$ lb.

Centre of Buoyancy

Sum of Moments divided by Sum of Functions of Areas, and result multiplied by Spacing.

$(145.00 \div 34.5) \times 3.5 = 4.203 \times 3.5 = 14.710$

C.B. of canoe body is 14.71 in. abaft Section No. 1.

Note.—As the C.B. is the centre of gravity of the volume of water displaced by the vessel, the centre of gravity (C.G.) of a solid mass (e.g., a lead keel) can be found by exactly similar methods, and its weight by similar methods to those used for calculation of displacement.

and the C.B., the force of buoyancy can be regarded as being a force equal to the weight of the yacht that supports her from below, and if this force can be considered as concentrated and acting through a single central point, the reader will be able to realise exactly what the C.B. consists of. Actually as mentioned, the vessel displaces a volume of water equal in weight to her own weight, and therefore the C.B. is the Centre of Gravity of the displaced volume of water. In order to find the position of the C.B., the C.G. of the displaced volume of water has accordingly to be calculated.

The C.G. of any body can be calculated either by Simpson's Rule or the Trapezoidal Rule. In either case the calculation is tabulated and the Functions of Areas ascertained. These, in turn, are multiplied by the Arm. This arm is the number of stations the section in question is abaft of the foremost one. Thus, the foremost section will have an arm of 0, the second section an arm of 1, the third section an arm of 2, and so on. This gives the Moments of the Sections which are summed. The Sum of the Moments is then divided by the Sum of the Functions of Areas and multiplied by the Interval between the stations.

It should be mentioned that a simple and accurate method of finding the C.B. without calculation is by cutting out the shape of the Curve of Areas from thin card or stiff cartridge paper and balancing it on a pin-point. If the beginner is working upon squared paper, he can, accordingly, get his section areas by counting and plot his Curves of Areas and make the necessary comparison of the Centres of Buoyancy without putting a single calculation on paper. The novice should be reminded that the body plan represents half-sections, and that having measured the half of the section that embodies the in-wedge, he must take the other half that is minus the out-wedge from the same side of the centre-line.

Before passing from the design of the canoe body of the hull, it might, however, be as well to investigate some of the features that make

for speed, as the qualities that govern this are inherent to this part of the design.

Any consideration of the speed potentialities of a yacht must be considered from the point of view of the inclusion of factors that make for speed and the exclusion of factors that detract from it.

Now in the comparison of a model with the prototype, or of a small yacht with a large one, it must be remembered that the wind has the same force for all vessels, whether they are small or large. Consequently the smaller vessel reaches her maximum potential speed sooner. When this has been reached and exceeded she becomes overdriven. The small yacht is, therefore, more frequently overdriven than her larger sister. This means that a relatively higher potential speed is even more essential to the smaller yacht than it is to the larger, and further, that she requires to be proportionately more powerful, even if this implies the sacrifice of something under very light weather conditions.

In her forward motion through the water a vessel creates a trough in which she is borne. That is to say, she creates a wave system having a crest at her bow and another at her stern. The faster she moves the farther apart are these crests, until the boat reaches her maximum potential speed.

This wave system is governed by the same laws as other waves. The greater distance apart the crests (regardless of the depth of the trough), the faster the waves travel, and the speed of the boat is, therefore, governed by her ability to set up a long-wave system.

This ability to set up a long-wave system is, in turn, regulated by the actual length that the vessel herself is able to use. In this connection neither L.W.L. length nor L.O.A. count, and it is *only* sailing length that matters. This is merely another way of repeating the old adage that length means speed.

This has been amply proven more than once in the case of steamships which have been lengthened to increase cargo-carrying capacity, and have gained an increase in speed whilst employing the same engines and boilers. All other things being equal, a longer and larger

vessel should be faster than a smaller one. A common instance showing the difference in potential speed due to difference in length may be cited. If one tows a 9-ft. dinghy at 5 knots behind a 25-ft. yacht, the yacht will slide through the water with hardly any disturbance, whilst the dinghy behind her creates a great fuss. In fact the dinghy is being overdriven whilst the yacht is maintaining her normal speed.

The designer, in trying to get high speed, is really striving to get the maximum sailing length possible, and the whole hull design resolves itself into that consideration as far as speed is concerned. Undoubtedly, quite apart from any considerations of rating rules, the necessity to get sailing length is the first consideration of the designer who aims to produce a speedy vessel, but other features have to be studied, and it may be said that all naval architecture is a compromise.

In arranging a design so as to get the longest possible sailing length, not only the profile and the angle it makes at the L.W.L. endings have to be considered. How far a yacht will use her overhangs is governed by her form, and in this connection the distribution of displacement is most important, and also her actual shape. A boat with a coarse model will have low-speed potentialities, as she will offer great resistance to forward motion. The fineness or otherwise of a vessel's form can be judged by her Co-efficients of Fineness. In order to obtain any useful data, these must be calculated on the canoe body without the keel appendage.

The reader has already been introduced to the Co-efficients of Fineness, and, in addition, to their use in estimating what a vessel's displacement is likely to be from her midsection, their main function is to enable the designer to judge the fineness or otherwise of a hull. In order to obtain any useful data, these must be taken on the canoe body only without the keel appendage.

The use of Co-efficients of Fineness is really only for purposes of comparison, and a great deal of experience is needed before they become of any use to the designer. The

beginner is, therefore, advised to be very chary of their use, as without the necessary experience he may be led astray.

Another feature that may detract from a boat's speed is skin friction. In this connection quality is of more importance than quantity. A comparatively small area of wetted surface that is not absolutely smooth may set up more skin friction than a larger surface of smooth skin. Provided the surface is really smooth, skin friction does not form a very large proportion of the total resistances, and the amount that can be saved is not sufficient to warrant any unreasonable cutting away of surfaces. Useless wetted surface is, of course, to be avoided, as is anything else that needlessly increases resistance.

Reference has been made to length in connection with wave-making, and also to the low speed potentialities of vessels having a coarse form. The connection between these facts should be explained. It was stated that waves having the same length between their crests travel at the same speed, regardless of the depth of the trough between them. This is correct, but it should be added that the flatter the wave the less energy does it require to propel at this maximum speed. In a similar way a vessel with a fine form that makes a flat wave requires less energy to propel at her maximum speed. Consequently the sweeter lined hull is easier driven, and reaches its maximum speed sooner, or alternatively requires less sail to enable it to attain this speed.

This applies to the design of any boat, but, above all, is a consideration when a designer is engaged on a class boat where the rating is a compound of hull and sail measurements. Careful consideration is needed in this respect in order to get the maximum combination of hull and sail under the rule.

The calculation of wetted surface is a matter that has little value from the model designer's point of view, but in case it is required the method of so doing is explained in a subsequent chapter.

Reference has already been made to tumble home. Tumble home was very extensively

used in mediæval ships, where it served many practical purposes, one of which was that it facilitated the efforts of the crew to repel boarders. These considerations do not apply, however, in designing a modern sailing yacht. Beginners in design sometimes employ tumble home in order to reduce the volume of the in-wedge, but, as has already been explained, this does not serve any practical purpose, as whether a boat gets down into the water and makes use of her overhangs entirely depends on the correct distribution of displacement, so that she makes a trough in the water for herself.

Another use of tumble home is when a boat has rather high freeboard, when a small

tumble home can be successfully employed to avoid any semblance of being wall-sided. The third and most practical use of tumble home is to keep the decks dry. A very clever use of tumble home for this purpose is made by Mr. Uffa Fox and Mr. Morgan Giles in their designs of racing dinghies.

As far as small models are concerned, tumble home serves no practical purpose, and is best omitted. In the case of larger models, such as an A-class or 6-m., it can be used to enhance the appearance of the model, though it will have no beneficial effect on her sailing qualities unless it be an infinitesimal reduction of windage surface on the weather side when the boat is heeled to a big angle.

CHAPTER VI

The Keel Appendage. Lateral Planes and the C.L.R. Forms of Keel Appendages. Drawing the Keel and Rudder. Comparison of Fore-and-Aft Position of Centre of Buoyancy when Vessel is Upright and Heeled. Calculation of Lead Keels.

THE canoe body of our boat is now complete and ready to receive its keel appendage, but, before proceeding with this, a short digression should be made in order to discuss a few points that have to be borne in mind in making any design.

For the purposes of explaining the processes of design, it has been found necessary to divide the subject into different sections, and hull design and sail design are dealt with under separate headings. It was also advisable to subdivide hull design into the canoe body and the keel. If this procedure had not been followed, the explanations would have been of necessity so involved that the student would not have a fair chance of grasping the different principles. Yet actually the canoe body and the keel are really parts of the same thing, and the hull, including the keel, must be considered as a single entity. Again, keel design and sail design are intimately connected and bear the strongest relationship. For instance, it is entirely useless to have the finest sail-plan in the world if it is above a keel that is unsuitable. In fact, a yacht design must be treated as a whole, whilst each of the component parts is considered not only in relation to itself, but in relation to the complete design.

Again, in drawing the plans of a yacht, the designer has always to bear in mind constructional difficulty. In this connection the model yacht designer, who has never built a planked boat, may be misled, as it is possible to carve out or build up features that would present the greatest difficulty of execution in plank building. If a hull planks up easily and sweetly, it follows that her *lines* are easy and sweet, and in all probability she will prove a good boat in consequence. Turns that are so abrupt that they present difficulty in planking, peculiar reverse twists and so forth should be avoided. Striving after effect by these means

is useless in yacht design, as it does not make for success. Success is attained by the simplest means, and the secret is beauty of line, balance, and a correct estimation of the type and dimensions likely to be successful under any given rating rule.

Now, before considering the vexed question of underwater profile for models, it would be well to consider what the keel has to do from a merely mechanical point of view as apart from its influence on performance. Take the case of an A-class boat in a heavy wind. Here we have a big, powerful type of model. On the one hand is a large sailspread trying to heel the boat, and at the other extreme a heavy lead keel striving to keep her upright. Shorn of all technicalities of heeling and righting moments, and stated in the plainest possible language, what is happening? The sail and the ballast are two forces at opposite ends of a lever, and each is striving for mastery. The strain on the arms of the lever is, of course, tremendous. In the case of the mast, the weather shroud takes the brunt, and both this and the chain-plate must be of great strength. Moreover, the bar-taut shroud immediately sets up a powerful downthrust on the mast, which in turn presses on the mast-step. This puts a great strain on the weather side of the boat, and, unless due precautions are taken, the sheer may be pulled upward at the chain-plates, with the result that the boat "hogs" (*i.e.*, the middle of the sheer is pulled upward and the ends droop). In order to obviate this in big, heavy craft, an internal stay is fitted from the gunwale in the neighbourhood of the chain-plates to the keel under the mast-step, as described in the chapters on building. Again, if it passes over a spreader (or cross-tree), the shroud through the spreader arm imparts a powerful side thrust to the mast, which in turn is supported by the lower shroud.

MODEL SAILING CRAFT

At the other end of this lever arm is the lead keel, and naturally there is an even greater side strain on this part of the structure. It is obvious, therefore, that the keel design must give sufficient strength and rigidity. Cases have been known in real yachts fitted with bulb-fin type keels, where the metal fin has bent and buckled under the strain. Apart from any considerations of displacement gain or loss, the bulb-fin type of keel is unsuitable for heavy displacement craft for constructional reasons.

On the other hand, the bulb-fin has certain advantages for light displacement craft. As will be explained a little later, the flat surface of the plate is more efficient, area for area, from the point of view of lateral resistance, than a keel presenting a convex surface. Also the actual angle between the plate and the canoe body of the hull is not detrimental to lateral resistance, but rather the reverse, and, finally, on a limited displacement this form enables the weight to be carried very low.

Conversely, the filled-in garboard gives greater displacement, and where it is desirable to have a greater displacement, this can be put in the garboard and the lines of the hull fined accordingly. In this connection stability comes under consideration. Now there are two kinds of stability that a boat can have—natural stability from the form of the canoe body, and artificial stability given by the ballast. A beamy, flat-floored, hard-bilged boat such as was shown in Fig. 18, has great initial stability, but loses this when heeled to any great angle. On the other hand, a narrow hull with an easy bilge will have very small initial stability in her hull form and must depend on her ballast. Stability due to hull form rapidly decreases to the vanishing point once the boat is heeled well over, whereas stability due to ballast gives a more powerful righting moment as the boat heels further. Again, the narrow, easy-bilged hull is easier to drive and has a higher potential speed. In designing it is therefore preferable to use an easily-driven form, putting a good proportion of displacement into the garboards and rely mainly on ballast to give the necessary stability.

From the real yacht builder's point of view the flat-plate type of keel has the advantage that it is easy and cheap to construct, especially on boats of a shallow type, and it is consequently used for craft such as Norfolk Broads yachts. However, the saving in cost on a model yacht would not amount to anything, and except in models, such as a Sharpie, where such a keel is strictly in keeping with the design, the model designer will be well advised to eschew the type altogether.

In designing a boat, the object is to create a hull that presents the minimum of resistance to forward motion and the maximum of resistance to sideways motion; in other words, the boat must make as much headway and as little leeway as possible.

If a boat is at rest in the water and we try to push her sideways, she will offer resistance. This lateral resistance is derived from her lateral plane. Whilst the boat is at rest, all this plane has equal value in resisting lateral movement, but when the vessel starts to move this is entirely altered. Before considering what happens when the vessel starts to move, it will be as well to explain what the Centre of Lateral Resistance is.

If a pole was taken and placed against the vessel's side and used to push her sideways, somewhere towards the centre of the boat a spot could be found where she would balance so that, when pushed, she would move bodily and evenly sideways. If the pole were placed too near the bow, the bow would swing away. If too near the stern, the stern would swing away. At just this one spot the boat would move evenly sideways. This is the C.L.R. It is, in fact, the centre of gravity of the plane enclosed by the underwater profile of the vessel and the L.W.L.

The method by which this is calculated is exactly similar to that used for the calculation of the C.B. from the Curve of Areas, and either Simpson's Rule or the Trapezoidal Rule can be used. It should, however, be noted that as the figure formed by the underwater profile changes rapidly, the ordinates should be spaced pretty closely together. No differentiation is made in this calculation between the canoe body

CALCULATING THE C.L.R.

and the keel appendage, although, as will be seen shortly, there is a great difference in their values as lateral plane.

Some designers do not take their rudders

yacht has to be divided up into suitable parts which are separately calculated. The combined centre can then be found quite easily.

The underwater profile of a full-keel yacht

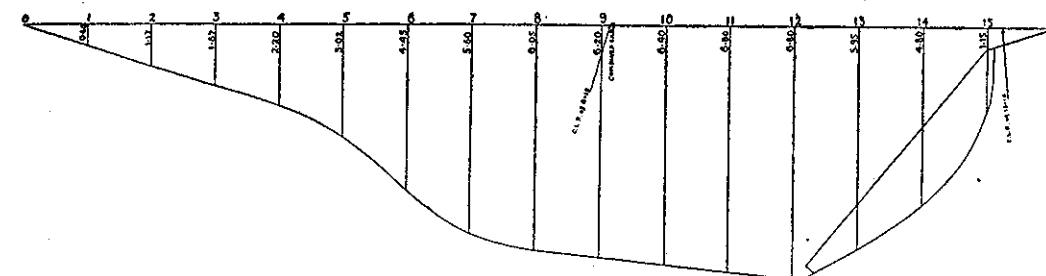


FIG. 30.—CALCULATION OF CENTRE OF LATERAL RESISTANCE (C.L.R.).

In this centre of part of lateral plane from Section 0 to Section 15 is calculated separately. The centre of part between Sections 15 and 16 is also found separately. The combined centre of these two parts is then found and is the C.L.R.

into calculation as lateral plane, others only take a portion. In the case of racing dinghies, where the larger part of the lateral area is represented by the centreboard and rudder, it is certainly essential to take the rudder into calculation. In the case of model yachts where it is usual to either lock the rudder amidships or close up the slides on the steering gear to

is shown in Fig. 30. For the purpose of calculating the C.L.R., this is divided into two parts on Section 15. The C.L.R. of Sections 0-15 is then found, also that of Sections 15-16. The combined C.L.R. is found by taking moments. This will be perfectly clear to the reader after reference to the worked example shown in the next column.

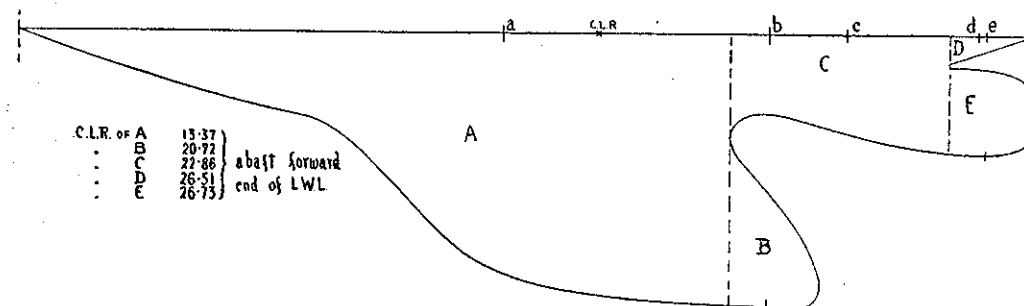


FIG. 31.

obviate movement when close-hauled, the rudder must obviously be considered as forming part of the lateral area. This to a small extent complicates the calculation, as the shape to be calculated becomes an irregular figure owing to the gap between the top of the rudder and the hull. Consequently the lateral plane bounded by the underwater profile of the

When the boat is of the fin-and-skeg type, as shown in Fig. 31, it will be necessary to further divide the lateral plane. The profile shown in this diagram is that of the little 36-in. model which we are designing, and it will be seen that it has proved necessary to divide the lateral plane into the five parts A, B, C, D and E. The centre of lateral

resistance and area of each part is then found separately, and the combined C.L.R. calculated by taking moments.

It will perhaps make the matter quite clear if it is mathematically stated as follows:

Let A equal area of part A and a the distance its C.L.R. is astern of the forward ending of the L.W.L. Let B and b likewise equal area and distance for part B, C and c for part C, D and d for part D, and E and e for part E.

Then the combined C.L.R. equals

$$\frac{[(A \times a) + (B \times b) + (C \times c) + (D \times d) + (E \times e)]}{(A + B + C + D + E)}$$

Now let us work out the C.L.R. of the yacht shown in Fig. 30.

CALCULATION OF C.L.R.

Station	Length of Ordinate	Multiplier	Functions	Arm	Moment
0	0.00	×	0.5 = 0.00	×	0 = 0.00
1	0.60	×	1.0 = 0.60	×	1 = 0.60
2	1.17	×	1.0 = 1.17	×	2 = 2.34
3	1.67	×	1.0 = 1.67	×	3 = 5.01
4	2.20	×	1.0 = 2.20	×	4 = 8.80
5	3.02	×	1.0 = 3.02	×	5 = 15.10
6	4.45	×	1.0 = 4.45	×	6 = 26.70
7	5.60	×	1.0 = 5.60	×	7 = 39.20
8	6.05	×	1.0 = 6.05	×	8 = 48.40
9	6.20	×	1.0 = 6.20	×	9 = 55.80
10	6.40	×	1.0 = 6.40	×	10 = 64.00
11	6.60	×	1.0 = 6.60	×	11 = 72.60
12	6.80	×	1.0 = 6.80	×	12 = 81.60
13	5.95	×	1.0 = 5.95	×	13 = 77.35
14	4.80	×	1.0 = 4.80	×	14 = 57.20
15	2.30	×	0.5 = 1.15	×	15 = 17.25
			62.66		571.95

The distance between the ordinates (i.e., their spacing) = 1.75 in.

Therefore Area of Lateral Plane = 62.66×1.75 sq. in. = 109.66 sq. in.

Centre of Gravity of Lateral Plane (i.e., C.L.R.) is

$$\frac{571.95}{62.66} \times 1.75 \text{ in. abaft Station No. 0 (forward L.W.L. ending)} = 15.98 \text{ in.}$$

Now in that part of the lateral plane aft of Station No. 15, owing to the sudden change in contour, the ordinates will have to be very much more closely spaced to get its correct area. This portion of the lateral area (i.e., between Stations 15 and 16) is then worked out separately in a similar way.

Its area is then found to be 0.80 sq. in. and

its C.L.R. is 0.4 in. aft of Station No. 15. As Station No. 15 is 26.75 from fore end of L.W.L., centre of this part is 27.15 in. aft of it.

The combined C.L.R. of the two parts of the lateral plane is now found by taking moments, using distance aft of Station No. 0 as the Arm.

	Area	Arm	Moment
Forward Part	109.66	$\times 15.98$	$= 1752.37$
After Part	0.80	$\times 27.15$	$= 21.72$
	110.46		1774.09

Therefore C.L.R. of whole Lateral Plane is $\frac{1774.09}{110.46}$ in. abaft Station No. 0 = 16.06 in.

A simple method of finding this combined centre, which is recommended as being quick and accurate, is to cut out the shape of the entire profile, including rudder, from cartridge paper and balance it on a pin-point.

Unfortunately, however, for the purposes of the designer, the position of the C.L.R. only remains constant so long as the boat remains motionless. In order to differentiate during the further discussion of this matter, we will refer to the true C.L.R. as the "Actual C.L.R." and the calculated C.L.R. as the "Calculated C.L.R."

Firstly, let us consider the whole lateral plane as if it were a flat plate. Now, as the boat moves forward it constantly meets undisturbed water, and consequently the resistance encountered by the forward part of the boat is greater than that encountered by the after part, which meets water that is already in motion. This increases the pressure at the bow and decreases it at the stern. Therefore the resistance of the forward part of the lateral plane to sideways movement is greater than that of the after part. The faster the boat moves, the greater this difference becomes. Whilst the boat was at rest the whole lateral plane was of equal value in resisting sideways thrust, but under way the forward part is the most valuable.

An exact parallel may be drawn from aerodynamics. The best illustration is to think of a leaf falling from a tree. This never falls

straight to the ground edgewise, but planes gently down from side to side. What actually happens is that the leaf has a natural tendency to keep its plane surface horizontal, and so it planes towards the ground, one edge being slightly lower than the other. As it gathers speed in that direction the centre of pressure shifts towards the leading edge, which consequently develops more lift than the back edge. The front edge then tilts upward and the momentum of the leaf is arrested. It then starts to fall again but with the other edge as leading edge, when the process is repeated. Thus the leaf comes down with a gently planing motion that reverses from side to side. The movement of the pressure towards the leading edge is known as the "shift of the centre of pressure towards the leading edge." This forward shift of the centre of pressure is also a very important consideration in sail design, but the designer has to remember that in this respect the design of keels and sails is analogous.

Now it has been shown that the actual C.L.R. moves forward, but there is also another consideration that must be taken into account. As has been pointed out, the lateral plane is in part the underwater body of the hull proper, and in part the keel appendage. Of these the canoe body presents a more or less saucer-shaped surface to resist lateral movement. Obviously, quite apart from actual area, this saucer will be easier to push sideways than the keel appendage, which is practically a flat surface. This difference is marked even at rest, but directly the boat starts to travel forward it becomes more marked, and the faster she travels the greater is the difference in power to resist side thrust. Now it is quite feasible to calculate this difference for various speeds, but, as the vessel does not maintain any given speed, but constantly varies, this would not be very useful. Moreover, the resistance would depend on the shape of the profile, and as this constantly varies with the angle of heel, it can be seen that it is impossible to gain any reliable data from these calculations. Again, the actual C.L.R. is very much influenced by the type of hull and shape of the

waterline plane, but these also vary. One is, therefore, forced to the conclusion that the actual C.L.R. moves about, and all that the calculated C.L.R. serves to show is the point from which its movement starts. Moreover, as the movement of the C.L.R. is different in each design, there can be no specific virtue in placing it at any given distance from the forward end of the L.W.L. It is usual to speak of the position of the C.L.R. in percentages of the L.W.L. from the forward end. Thus, in a 100-ft. waterline boat, if the C.L.R. was at 58 per cent. L.W.L., it would be 58 ft. from the forward L.W.L. ending.

Some designers pin their faith to given positions for placing the C.L.R., but, as has been shown, nothing definite can be based on such data. All that can be determined is what actually suits any given boat in relation to her sail-plan and general design. The main use of the calculated C.L.R. is, therefore, to use as an assumed centre for reference when the sail-plan is being designed and placed over the hull.

Our next consideration is the shape of the lateral plane. It is a generally accepted theory that the actual C.L.R. moves forward. Whilst this is true as regards the C.L.R. of the canoe body and the keel appendage taken separately, it does not follow that the actual C.L.R. of the whole underwater hull moves forward. The movement of the actual C.L.R. of the whole is governed by the area of the keel in proportion to that of the canoe body, the position of the former under the latter, and, above all, by the contour of the leading edge.

In the case of a yacht (Fig. 32, Diagram A), where the area of the canoe body is equal to that of the keel, it is obvious that when the vessel is at rest the C.L.R. will fall on a line joining the separate centres of the canoe body and the keel, exactly midway between them. As the keel becomes increasingly more efficient in relation to the canoe body when the vessel travels forward, a tendency will be produced to drag the centre of the whole towards the C.L.R. of the keel. On the other hand, the centre of the keel, taken by itself, moves forward more rapidly than that of the canoe body. How fast this forward shift in the keel takes

place is entirely governed by the angle of the leading edge. If the forward edge of the fin was vertical when the boat was on an even keel, the forward shift would be much more violent than if it were a long raking line. The angle of incidence of the leading edge is, therefore, of great importance, and an angle of about 45 degrees will be found very suitable. It will be seen that in this diagram the leading edge of the fin is at approximately the angle recommended. The skeg and rudder were omitted from this drawing in order not to complicate matters.

to move towards the centre of the flat keel is compensated by the drag of the leading edge. It will be seen that the only method by which this can be done is by placing the centre of the keel at the *correct* distance *ast* of the centre of the area of the underwater body. If this is not done, steering tendencies will be introduced that in the case of a model will prevent her ever performing to her owner's satisfaction, and in a real yacht may be highly dangerous. As a proof of this contention, it has been found that some yachts require lee helm to prevent them running off the wind. If this tendency

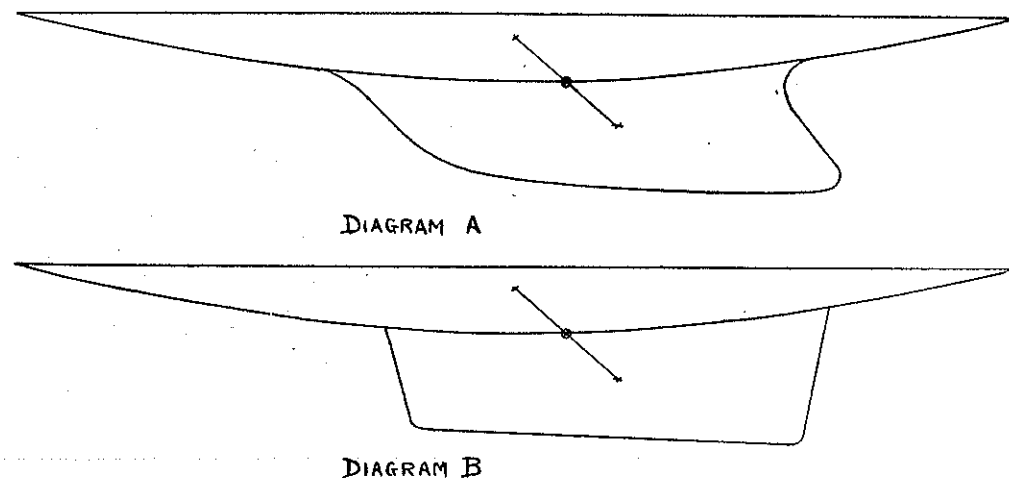


FIG. 32.—CENTRE OF LATERAL RESISTANCE. (SEE TEXT).

In Fig. 32, Diagram B, another shape of fin is shown having approximately the same area and C.L.R. The combined C.L.R. would be the same as for Diagram A whilst the yacht was at rest. When, however, she started to move forward, the steep angle of the leading edge of the fin would cause a violent forward shift of the centre of lateral resistance of the appendage, and consequently of the actual C.L.R. of the whole lateral plane, which would move forward far faster than that of the yacht in Diagram A.

The aim of the designer will be to arrange the angle of the leading edge and place the area of the keel under the canoe body in such a way that the tendency of the actual C.L.R.

to run off is present in a large yacht, it may prove very dangerous, as it may, under certain conditions, develop to such an extent that the rudder is powerless to counteract it. It was undoubtedly this feature that caused the 100-ft. L.W.L. yacht "Satanita" to ram and sink the "Valkyrie" on the Clyde. Another incident which occurred at Cowes was when the schooner "Germania" took charge and ran off so much that the wind flattened her out before the sheets could be eased off, and she was thrown on her beam-ends with the deck buried in water to the skylights, with the result that she nearly filled and sank. A third noteworthy case was in the Trials to select the "America's" Cup defender against "Sham-

rock II." when "Independence" took charge and almost ran ashore before the crew could get sail off her.

Again, if the centre of the appendage is too far forward to commence with, the sail-plan of the boat will also have to be too far forward in order to enable the model to fill away and keep sailing. If, on the other hand, it is too far aft, the rig will have to be too far aft in order to make her point to windward at all.

Now it has already been shown that the tendency of the C.L.R. of any body is to shift towards the leading edge as forward progress is made through the water, and, further, that the power of a plane surface (such as the appendage to a yacht) increases its power more rapidly than the canoe body of the vessel. It is, therefore, possible to arrange the appendage under the hull so that, although the C.L.R. of the appendage shifts towards the leading edge whilst the C.L.R. of the canoe body moves similarly, yet the increased power of the appendage in proportion to the power of the canoe body drags the combined C.L.R. of the whole lateral plane either forward or aft in accordance with the relative positions of appendage and canoe body.

In consideration of the relation of the C.E. of the sail-plan to the C.L.R. of the hull, it must be remembered that the C.E. also is subject to shift of the centre of pressure towards the leading edge. In spite of this, however, it would be extremely difficult to arrange the C.E. over the C.L.R. in such a manner that forward movement of the C.L.R. would be counterbalanced, but, even if this was accomplished, it would not be an ideal arrangement by any means, as there would be a conflict of opposing forces, and any such balance would be a compromise which would result in loss of speed. On the other hand, it would obviously be impossible to arrange the C.E. in such a manner as to counteract the effect of the C.L.R. moving aft. If, however, the appendage is arranged under the canoe body in such a way that the actual C.L.R. is more or less constant, it only remains to design a suitable sail-plan to harmonise with the underwater profile of the yacht. The

question of sail-plans is dealt with at length in a subsequent chapter, and has only been touched on at this point in order to explain its relationship to the keel appendage.

The design of a solid-keel type model presents much greater difficulty, even to an experienced designer, than one of the fin-and-skeg type, and the novice is, therefore, advised to make his first essays with boats of the latter type. When he becomes more expert he will be in a position to form his own judgment on these and similar subjects. The reason why the fin-and-skeg type is easier to design is that the appendage is almost a thing apart from the canoe body, and can be treated as having its own entrance and delivery, whereas the solid-keel must, of necessity, be considered as part of the hull proper. Consequently, great care is required to avoid converging stream-lines in the garboard at the midships section. Early attempts to avoid the *d* measurement, which has formed part of every rule in force in this country since the L. and S.A. formula, in many cases proved disastrous. Apart from the resistance to forward motion caused by the pressure on the water in the garboard at the midsection, the sudden release of this water abaft the midsection, with its consequent increase of speed across the after deadwood, generated a turning movement and had the effect of a strong weather helm. In modern boats designers have very cleverly avoided this choke by keeping the lower part of the forward waterlines full, in order to avoid forcing any unnecessary water down into the garboards. In addition to this, the entry is kept short in proportion to the delivery, the latter being long and easy to provide for the gradual release of the pressure.

Whilst these considerations are particularly applicable to solid-keel boats, they also apply to fin-and-skeg types, but with the solid-keel there are a number of further points that have to be taken into account. The considerations of a model and a full-size yacht differ in some respects, though practically all these differences arise from either the reduction in size or the fact that a model has to sail herself, whilst the yacht has a crew aboard.

In the model very definite steering is required, whilst in the prototype the ability to turn quickly is essential. The fact that in the model the fin-and-skeg is quicker in its action than the solid-keel might at first sight make one think that the fin-and-skeg would be more quickly manoeuvred in the bigger yacht. This, however, is not the case, as the rudder of the fin-and-skeg type is much further aft than can be arranged in the pure keel form, and its action is slower as the turning couple is longer. Consequently, the rudder in the solid-keel form facilitates quicker handling in spite of the boat being actually harder to turn. Further, the crew in the yacht is always in a position to enhance the effect of the rudder by skilful sail handling, whilst the model has to rely on the rudder unaided.

Weighing up the whole question from the model yachtsman's point of view, the fact that a much smaller angle of rudder is necessary to keep the boat before the wind in the fin-and-skeg type means that there is less resistance to forward motion, and, further, as there is no skipper aboard to anticipate the variations in the wind, the fin-and-skeg is the more amenable to control. Whilst these considerations do not affect the full size, they are important to the model designer, and it would therefore appear that off the wind the fin-and-skeg model has the advantage over the solid-keel. With regard to the windward work of the two types, there is little to choose provided the boats are equally well designed.

Admittedly in heavy displacement types of craft, such as the A-class or 6-m. models, the solid-keel type would certainly appear the most desirable and suitable to the spirit of the rule, but if it is to stand any chance in all-round sailing against the fin-and-skeg, it must be extremely well designed and tuned-up to perfection.

The present little boat is accordingly being designed with a fin-and-skeg, as it is not advisable for the novice to tackle any more complications than are absolutely necessary until he has mastered the rudiments of the art of designing.

As has been shown, it is desirable for the

skeg to be well aft in order that the rudder may be favourably placed. Now exactly the same principles apply to the skeg as apply to the main fin, and if the leading edge of this is at a steep angle of incidence there will be a sudden violent increase of grip. This in the skeg right aft will drag the actual C.L.R. of the whole lateral plane aft, with the result that the boat will run off the wind. Now any tendency that causes the actual C.L.R. to move aft must be eliminated, and the leading edge of the skeg should therefore be almost parallel with the L.W.L.

The rudder is hung on the after side of the skeg. As the shape and size of this is discussed later, it will be sufficient to mention at this stage that the rudder-post of a model should be very nearly vertical. There are a number of reasons for this, but one of the most important to a model yacht designer is that a rudder that has a vertical post lends itself more readily to the use of the Braine steering gear than one with a heavy rake.

The question now arises of the proper proportion of lateral area to give any boat. In this connection it has already been shown that greater speed through the water increases the amount of grip from any given lateral area, and it follows that faster craft require smaller lateral area than slower boats. This, in turn, gives a further gain in speed, as the boat with the smaller keel area has less resistance due to wetted surface.

The side thrust of the wind on the sails can be mathematically resolved into forward motion and leeway, and it follows that the amount of leeway is dependent on how much of this force the boat is unable to absorb by forward motion. The yacht that presented no resistance to forward motion would make no leeway, but, as it is impossible to achieve this ideal, it would appear that a certain amount of leeway is inevitable, but it can be reduced to very small proportions by correct design, by taking advantage of the increased resistance to lateral motion arising from increased speed through the water.

Experience must be the only guide as to the exact amount of lateral area required by any

given boat, and in this connection the sail area is also a factor to be reckoned with.

The rake of the bottom edge of the keel has also to be considered. This feature was introduced in yachts designed to the late I.Y.R.U. Rule in order to lessen girth measurements, but the rule has now been altered and there is no reason for its introduction in a design unless it serves some useful purpose. Should it be desirable to introduce this feature for any reason, it should be remembered that a keel raked on the underside becomes a continuation of the leading edge and must be given the same consideration as regards rake. Again, when a violent rake is given to the bottom of the keel, the forefoot is reduced unduly with a loss of weatherliness. Craft, such as drifters, which lie head-on to their nets, have a steep rake to the underside of the keel and a deep heel, which makes them lie steadily to their nets without sheering about.

As regards the length of the bottom of the keel, if this is unduly short it may be found necessary to make the keel waterlines coarse in order to get the lead sufficiently low; but, even if this is done, there will be the possibility of a further evil in that the ballast, being too concentrated in a fore-and-aft direction, may tend to make the boat jerky in her motion. On the other hand, if the ballast is too spread, the action of the vessel will be slowed until she becomes sluggish in a seaway.

Unfortunately no particular proportion can be laid down to guide the novice as to length of keel required on any given waterline, and, until the necessary experience has been acquired, he will do well to study the performance of models he knows, and mould his ideas on the most successful. This advice is not intended to imply that the work of others should be slavishly copied, but ship designing is an ancient art, and a lifetime would not be long enough to make satisfactory progress if the experience of generations is to be ignored.

One of the most frequent faults made by the beginner in design is to think that everything that has gone before can be immediately improved, and consequently he produces a

boat that is a "box of tricks" from start to finish. This is not the way to make progress. If the designer thinks he can improve any particular feature he should make his model orthodox in all other respects. The exact effect of the novelty can then be noted. If, on the other hand, a number of new features are incorporated in the same boat, the effect of each cannot be judged, and no useful knowledge is acquired thereby.

It has been decided to make our little boat a fin-and-skeg model, and the appendage is accordingly drawn in on the profile drawing. In drawing in the profile of the keel appendage we automatically fix the position of the C.L.R. In the present instance the C.L.R. has been placed at approximately 55.5 per cent. of the L.W.L. The next question is to draw in the keel waterlines and sections.

The first keel waterline to be drawn in will be that at the greatest thickness of the bulb portion of the fin. Now the design of the bulbed part of the fin differs from the design of the hull as it is a totally submerged body and therefore purely a matter of streamlining. This implies the entry being short in comparison with the delivery, and the position of the greatest section should come at about one-third of the length of the keel appendage at this waterline level.

In designing the fin it must be remembered that the greatest breadths of the various waterlines must merge from one waterline to the next so that all these points can be joined up in the same way as were the greatest breadths in the canoe body.

Having drawn the waterline at the greatest thickness of the bulb part of the fin, the next step is to complete the section at its greatest width, joining it up to the canoe body and fairing so that the body and fin merge into one harmonious whole.

When this is completed a diagonal must be struck through the turn of the garboard, as shown on the body-plan of the little boat. This should be so arranged as to finish at the ends of the fin. This diagonal must then be drawn in its own plane, and it is a most important line, as the boat's performance can

be entirely marred by a coarse garboard diagonal. This diagonal indicates the turn of each section at the garboard, and can be looked on as showing the passage of water through the boat's garboards. The reason why a coarse line is so detrimental at this point is that this is the deepest part of the hull and therefore the resistance to a coarse line is greater than at any point nearer the surface.

The other waterlines in the fin can now be drawn in and faired to complete the remaining sections. The rudder has to be designed next to complete the profile of the boat. As has already been stated, for model work a vertical rudder-post is better than one with a rake, as it allows the Braine gear to function more easily, but in a full-size yacht this consideration is not present, and when the rudder is hung on the after edge of a full keel, a raking rudder-post will give the best shape for the lateral plane. In a rudder with a raking rudder-post a little width at the top will help to prevent eddies, but the centre of the area should come about half-way down. For the rudder of a fin-and-skeg type boat a good width is desirable, and, as a matter of fact, a rudder similar to that which is shown on the plan of our little boat has been found the best by experience gained from numberless experiments with different shapes and sizes. The width of this rudder will hold the boat and prevent her from broaching in the fiercest slams.

With regard to the question of actual area for the rudder, certain percentages have been laid down by various authorities, and these work out all right when applied to exactly the type of boat for which they are intended. Boats, however, vary; lateral planes vary, both in shape and area; waterline planes vary—not only as between boat and boat, but in the same boat, according to her angle of heeling. Therefore the best guide as to size of rudder is experience, and similar boats provide a good guide for the beginner.

The shape of the horizontal sections through the rudder is a little point that needs watching. The rudder should fit the after part of the keel properly and offer as little resistance as possible. In fact, it should be a continuation of the

streamlines, and the blade should taper away to a fine after-edge.

This completes our hull, but we still have to calculate the final displacement and prove the design before drawing the lead line.

The method, which has been described, of drawing the lines about a balanced diagonal is *not* to be considered as a system of hull balance. It is simply a geometrical method of drawing a symmetrical hull. It is, however, a fact that it produces a balanced boat, provided it is properly applied. This, however, does not absolve the designer from the necessity of proving the balance of his hull.

In Chapter IV we explained the necessity of a yacht maintaining the same fore-and-aft trim at all angles of heel, and we are now about to test our design in this respect. This is done by comparing the position of the C.B. of the hull on an even keel with the position of her C.B. when heeled.

The first step is to draw an inclined waterline through the intersection of the centreline and L.W.L. on the body plan. Visual comparison of the in- and out-wedges is sufficient to tell us that the in-wedges are considerably larger than the out-wedges. As the boat would put in more than she takes out, it is obvious that she would rise in the water accordingly. It would be quite possible to calculate the heeled displacement and see how much more this would be, and then by calculation of the heeled waterline plane to see how much she should be lifted to get the correct displacement. This, however, would entail quite an amount of calculation which experience has shown to be unnecessary, and it will be quite sufficient for purposes of comparison if the immersed portions of the heeled sections are taken as shown.

The C.B. of the inclined hull can be ascertained by taking the section areas, tabulating and working out the C.B. in a similar manner to that of the upright hull.

In making the comparison of fore-and-aft positions of C.B. of hull when upright and heeled, it is usual to consider the yacht as being heeled to her maximum effective angle. This is usually taken as being when the gunwale

is nearly awash, and this practice has been followed in working out the example shown.

If the comparison is made for an extreme angle of heel in this fashion, and satisfactory results are obtained, it may safely be assumed that the intermediate angles of heel would show equally satisfactory tests.

The heeled waterlines are shown on Fig. 27, though the actual measurement of the sections for comparison is not taken until the keel has been added to the hull as in Fig. 28. Possibly it might have been a little clearer if these heeled waterlines had been repeated in Fig. 28 as well,

but the reader should have no difficulty in understanding this matter, and it was desired to show the design as a finished drawing in the last diagram, and so a number of the lines used for working-out purposes were omitted from it.

As we have to work out the final displacement of the model and the upright C.B., which is required for planning the lead keel, this will give us part of the figures required for proving the hull. It will be remembered that either Simpson's or the Trapezoidal Rule can be used for these calculations, and in this example the authors have used the latter.

CALCULATION OF DISPLACEMENT AND COMPARISON OF POSITIONS OF CENTRE OF BUOYANCY WHEN VESSEL IS UPRIGHT AND HEELED

Whole Hull Upright						Whole Hull Heeled					
Section Nos.	Areas of Sections.	Multipliers.	Functions of Areas.	Arm.	Moments.	Section Nos.	Areas of Sections.	Multipliers.	Functions of Areas.	Arm.	Moments.
1	0.00	X 0.5	= 0.00	X 0	= 0.00	1	0.00	X 0.5	= 0.00	X 0	= 0.00
2	2.20	X 1	= 2.20	X 1	= 2.20	2	2.63	X 1	= 2.63	X 1	= 2.63
3	7.10	X 1	= 7.10	X 2	= 14.20	3	8.18	X 1	= 8.18	X 2	= 16.36
4	13.88	X 1	= 13.88	X 3	= 41.64	4	15.05	X 1	= 15.05	X 3	= 45.15
5	20.70	X 1	= 20.70	X 4	= 82.80	5	21.92	X 1	= 21.92	X 4	= 87.68
6	20.28	X 1	= 20.28	X 5	= 101.40	6	21.60	X 1	= 21.60	X 5	= 108.00
7	11.64	X 1	= 11.64	X 6	= 69.84	7	12.43	X 1	= 12.43	X 6	= 74.58
8	4.40	X 1	= 4.40	X 7	= 30.80	8	5.44	X 1	= 5.44	X 7	= 38.08
9	0.00	X 0.5	= 0.00	X 8	= 0.00	9	0.53	X 0.5	= 0.25	X 8	= 2.08
					80.20						87.51
					342.88						374.56

Up to this point the figures used for the two calculations (Displacement and Centre of Buoyancy) are worked out by the same methods, but in finding the Displacement only the Moments are not required, so that the Functions of Areas are not multiplied by the Arm.

Displacement

Sum of Functions of Areas = 80.20
Multiplied by Section Spacing = 3.5
280.70

Displacement in cubic inches = 280.70
Displacement of vessel in Fresh Water:—
280.70 ÷ 27.65 = 10.33 lb.

If yacht is being calculated for Sea Water, divide by 27 in. instead of 27.65.

Centre of Buoyancy

Sum of Moments is divided by Sum of Functions of Areas and the result multiplied by the Section Spacing.

(342.88 ÷ 80.20) × 3.5 = 14.962.

The Centre of Buoyancy is 14.962 in. abaft Section No. 1.

Centre of Buoyancy

Sum of Moments divided by Sum of Functions of Areas and the result multiplied by the Section Spacing.

(374.56 ÷ 87.51) × 3.5 = 14.91.

The Movement of C.B. on heeling is therefore 0.05 in. on L.W.L. of 28 in. = approx. 0.16 per cent. Had the method of balancing been used, this movement is so small it would not have been detected, and it can be ignored.

Note.—This calculation only gives the fore-and-aft position of the Centre of Buoyancy. The method of finding its height and transverse position when the vessel is heeled is given in the next chapter.

It will not be forgotten that the C.B. can equally well be found by plotting the Curve of Areas on reasonably stiff paper, cutting the shape out and balancing on a pinpoint.

MODEL SAILING CRAFT

In the case of the worked example, a very small discrepancy is found but it is so small that it can be ignored.

Now if the C.B. of the boat, when heeled, is found to be in the same fore-and-aft position as when on an even keel, it is obvious that the craft will not alter her fore-and-aft trim. If, however, the C.B. is found to have moved forward, obviously the boat will rise forward and sink at the stern, which is known as "squatting." If, on the other hand, it has moved aft, the reverse will take place and she will "bore." If either of these things occur a

entail squatting. If any of these faults are present, the character of the diagonals will reveal them and clearly indicate the alteration required.

The upright and heeled Curves of Areas should now be plotted on the same base line for the purposes of comparison (see Fig. 33). On looking at these it will be seen that, though the two lines are not absolutely parallel, they are very nearly so, which of course is as it should be, since if the heeled curve varied violently in any part from the upright curve it would be a sign that there was a considerable

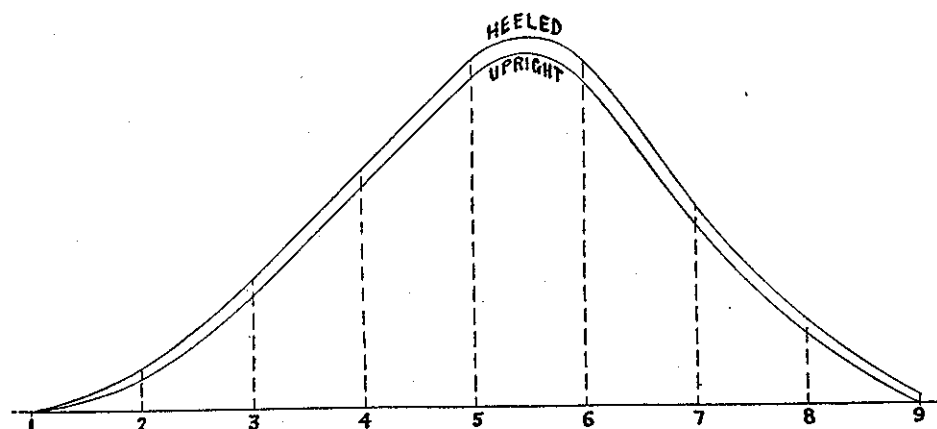


FIG. 33.—COMPARISON OF CURVES OF AREAS WHEN VESSEL IS ON AN EVEN KEEL AND HEELED.

re-adjustment of shape will be found necessary.

By the method that has been employed, it has been practically assured that little or no change in fore-and-aft trim will occur, but it is as well to point out features that would prevent correct balance in this respect. Had the L.W.L. been drawn too fine forward in proportion to its after part, forward sections would have been developed that had not sufficient reserve buoyancy in their topsides, and the boat would stoop when heeled. Too much reserve buoyancy aft would cause her to rise aft, and she would stoop in a similar way. Excessive fullness in the buttock lines aft would bring the C.B. of the out-wedge too far aft, and, as this feature would cause the topsides to be relatively leaner, this would

discrepancy between the topsides and underwater body, and indicate that the hull was not a homogeneous whole. It should be noted that in order to emphasise the comparison between these curves a different scale has been used in drawing them to that used in earlier figures.

We are now in a position to draw our leadline, and we know that the total weight of our yacht comes out at 10.3 lb. Now it would be possible to tabulate every part of the boat and work out the exact weight, but wood in itself varies immensely, and for a model, at all events, experience is the only guide as to what weight the builder will require to complete his hull.

In the case of this little boat it should be quite possible to build her with everything on except the lead keel on a weight of 4 lb., which

DRAWING THE LEADLINE

leaves 6.3 lb. weight for the lead keel. It may be added that in judging the amount to leave for the boat, the hull is the main factor, so that the weight will largely depend on the scantling used for a planked boat, or the thickness left after hollowing out a bread-and-butter model.

Having determined the respective weights of lead and boat, the next step is to strike in a leadline that will not only give the correct weight of lead ballast, but place its C.G. correctly so as to trim the boat on her proper waterline.

We have already calculated the position of the C.B., and, as will be explained in a later chapter, the C.G. of the whole mass of the boat, including the lead keel, must come in the same vertical line as the C.B. Now, if the C.G. of the whole boat, excluding the lead keel, was in the same vertical plane in a fore-and-aft direction as the C.B., all that would have to be done would be to arrange the C.G. of the lead immediately underneath the C.B. If, as is most usually the case, the C.G. of the boat, less lead keel, is not in the same vertical plane in a fore-and-aft direction, the C.G. of the lead keel would have to be arranged in such fashion that the lead keel counterbalances this, and, by bringing the combined C.G. of the mass back into the same plane, trims the boat correctly in a fore-and-aft direction.

The manner in which the C.G. of the lead is arranged in relation to the C.G. of the rest of the boat is best explained by a simple instance. If the C.G. of the hull and rig was found to come 1 in. ahead of the C.B. whilst the keel was to weigh three times as much as the rest of the boat, then the C.G. of the lead would have to come $\frac{1}{3}$ in. abaft the C.B.

In the case of our little boat, the C.G. of the hull and rig will come about $\frac{1}{2}$ in. forward of the C.B., and, therefore, if the boat is to trim correctly, the C.G. of the keel weight of 6.3 lb. must be placed .317 in. behind the C.B., or approximately $\frac{3}{8}$ in.

Now the weight of a cu. foot of cast lead

is 709.5 lb. and that of a cu. inch of cast lead 6.36 oz. This, of course, varies with the purity of the metal, and for the purposes of calculating the lead keel of a model, a cu. inch of lead can be taken as 6 oz. As our lead keel is to weigh 6.3 lb., we shall want approximately 16.8 cu. in. of lead.

Knowing the weight required and position for the C.G. lead, the next step is to strike the leadline. Now there is no way to do this except by the method of trial and error. Accordingly, a tentative line is drawn and the volume of lead below it and its C.G. are calculated. Unless a lucky guess has been made, this will be wrong, but with the figures obtained a new line can be drawn which will give nearer the desired result, and the process must be continued until the correct line is found. When a little experience has been gained, the first attempt should be pretty near, but the second calculation will be such a good guide as to the further alteration needed that the third attempt should be successful, and the correct line easily found.

The novice may wish to get his results without all these figures, and if he makes his boat and fittings, and assembles her, he can ascertain the necessary data for his lead keel in the following manner. By weighing the boat it can at once be seen how much lead is required to bring her down to her desired L.W.L., but allowance must be made for the weight of the wooden keel pattern, which will be cut off in due course. The next thing to ascertain is the position of the C.G. of the lead keel in order to trim the yacht correctly in a fore-and-aft direction. This is ascertained by the practical method of putting the boat afloat with a weight equivalent to the desired weight of lead suspended under her from a screw-eye put into the bottom of the wood keel pattern. In order to trim the boat to her correct waterline, the suspended weight will have to be heavier than the actual keel will be, as the displacement of the suspended weight will be absent when the model is completed.

CHAPTER VII

Fore-and-Aft Trim. Calculation of Centre of Gravity. Vertical Curve of Areas. Calculation of Height of Centre of Buoyancy. Finding Transverse Position of Centre of Buoyancy when Vessel is Heeled. The Metacentre. Stability Calculations. The "Metacentric Shelf" System of Balance.

ALTHOUGH the main principles governing yacht design apply alike whether one is designing a 36-in. L.O.A. model or an "America's" Cup Challenger, obviously calculations for a small model need not be so elaborate as those for a larger vessel. At the

In Fig. 34 is shown the profile of a yacht floating at her correct waterline. The C.G. is in the same vertical position as her C.B. in a fore-and-aft direction. If a weight aboard her is moved forward so that the C.G. moves forward as in Fig. 35, the vessel will imme-

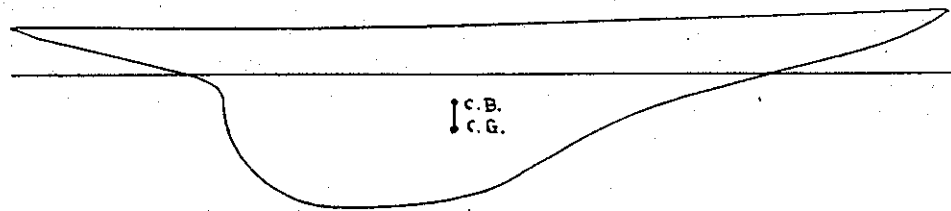


FIG. 34.

same time it is a great advantage to the model yacht designer to understand something of the more advanced theory of his subject.

As has already been explained, the buoyancy of a vessel is equivalent to a force supporting her from beneath, and this force can be

diately adjust herself to this new condition and the C.G. will automatically place itself under the C.B. so that the craft is by the head. It will be noticed that as her head goes down, the C.B. moves forward somewhat because the stern is lifted as the bow is depressed. This

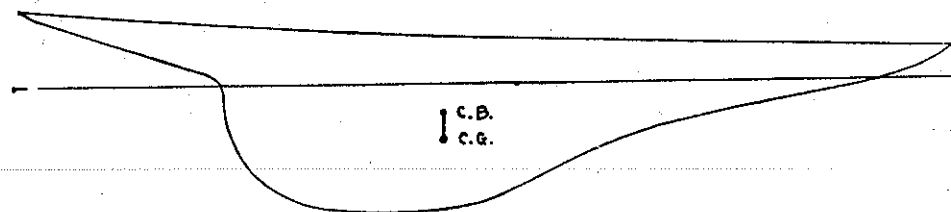


FIG. 35.

considered as working upwards through a point which is the Centre of Buoyancy. On the other hand the Centre of Gravity is the resolved point through which the whole weight of the vessel can be considered to be acting downwards. If the C.B. is considered as a nail on which the weight of the boat is hung and the gravity as a weight, it is obvious that the C.B. and C.G. must come in the same vertical line.

to a small extent offsets the effect of the weight trimming her, but nevertheless she goes by the head as shown in the diagram.

We know the fore-and-aft position of the C.G. must coincide with the C.B. We also know that the C.G. must fall on the centreline of the vessel and this gives us its transverse position. What we do not know is how to calculate its fore-and-aft position and height.

VERTICAL DISPLACEMENT CURVES

In a large vessel most elaborate calculations are made to ascertain the position of the C.G. The method employed is to take each part of the boat separately and calculate its weight and the individual C.G. All these results are tabulated, and by taking Moments the combined C.G. of the mass is found. This can be done from the bow for the fore-and-aft position, or above and below L.W.L. to find the height.

This elaborate performance is unnecessary in the case of a model yacht, and a little experience will soon teach the model yacht designer, who is also a builder, where his Centre of Gravity will come to within a very narrow margin of error.

If, however, the designer wishes to calculate either the fore-and-aft position or height of his C.G. without going through the whole laborious process outlined above, he can get a very close approximation by the following method. Divide the total weight of the yacht into several main divisions, as, for instance, the weight of the rig taken at the C.E., the canoe body of the hull taken at the centre of its profile, the deadwood taken at the centre of its profile, and the lead keel taken at its C.G. (which may be computed or estimated closely), etc. As an instance the little 36-in. yacht would be worked out as follows to find the height of the C.G. :—

Item.	Above L.W.L.	Weight.	Arm.	Moment.
Rig		0.8 lb.	18.80 in.	15.04
Deck, Hatch & Fittings.		1.0 "	2.25 "	2.25
Hull (painted)		1.7 "	0.45 "	0.77
		<u>3.5 lb.</u>		<u>18.06</u>

Item.	Below L.W.L.	Weight.	Arm.	Moment.
Deadwood, Skeg & Rudder		0.5 lb.	3.60 in.	18.00
Lead		6.3 "	5.70 "	35.91
		<u>6.8 lb.</u>		<u>53.91</u>

$$\text{C.G. below L.W.L.} = \frac{53.91 - 18.06}{3.5 + 6.8} = 3.48 \text{ in.}$$

Apart from anything else, two important lessons can be learned from this little calculation—the importance of minimising weight

aloft and the necessity of getting the lead ballast as low as is practicable.

* * * *

In a previous chapter we have seen how to calculate the fore-and-aft position of the Centre of Buoyancy, and we know when the vessel is on an even keel this must fall on the centreline. The vertical position of the C.B. is found by taking out a vertical Curve of Areas. With a vertical base line, plot the ordinates horizontally at intervals equal to the spacing of the waterlines. The top ordinate

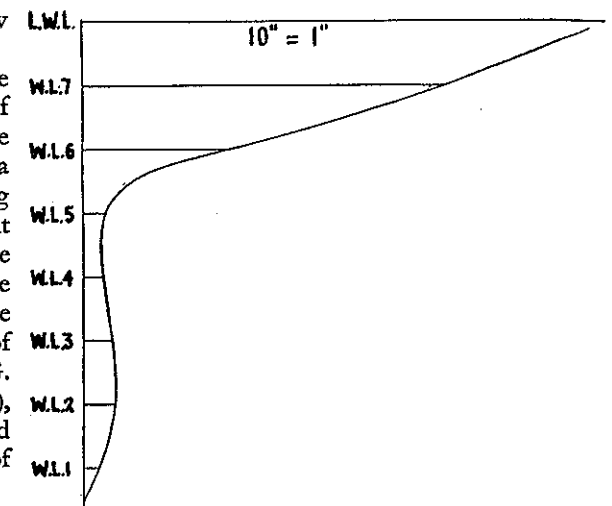


FIG. 36.—VERTICAL CURVE OF AREAS (OR DISPLACEMENT CURVE).

represents the L.W.L. and its length is plotted to any suitable scale to represent the area of the L.W.L. plane (*i.e.*, area of one-half L.W.L. plane). The lower ordinates similarly correspond to the various waterline planes. This is shown in Fig. 36 for our little 36-in. boat. The C.B. can now be found either by cutting out the shape of the Displacement Curve and balancing, or calculated by either Simpson's or the Trapezoidal Rule. If calculated, the displacement can be taken out at the same time and will serve as a check on our calculation by means of the section areas. As an example we have worked out the vertical position of the C.B. of this boat :—

MODEL SAILING CRAFT

W.L. Nos.	Areas of W.L.'s.	Multipliers.	Functions of Areas.	Arm.	Moments.
L.W.L.	82.70	$\times 0.5 =$	41.35	$\times 0 =$	0.00
7	57.22	$\times 1 =$	57.22	$\times 1 =$	57.22
6	23.24	$\times 1 =$	23.24	$\times 2 =$	46.48
5	3.25	$\times 1 =$	3.25	$\times 3 =$	9.75
4	3.16	$\times 1 =$	3.16	$\times 4 =$	12.64
3	4.49	$\times 1 =$	4.49	$\times 5 =$	22.45
2	4.96	$\times 1 =$	4.96	$\times 6 =$	29.76
1	2.55	$\times 0.5 =$	1.28	$\times 7 =$	8.96
			<u>139.55</u>		<u>187.26</u>

As the waterline spacing is 1 in., the Functions of Areas $\times$ Spacing = $139.55 \times 1 = 139.55$ cu. in. There is a very small portion of the keel below W.L.1; its area can be calculated or it will be near enough if we estimate it at 1 cu. in. The total displacement is, therefore, 140.55 cu. in. When we calculated this on the section areas we found it as 140.35 cu. in. for the half-body, so this is quite near enough to pass.

To find the C.B., the Moments are divided by the Functions of Areas and the result multiplied by the Spacing. We, therefore, get $187.26 \div 139.55 \times 1 = 1.35$. The small portion of keel below W.L.1 is too small to influence the result, so that C.B. is 1.35 in. below L.W.L.

Having dealt with the C.B. when the vessel is on an even keel, we must consider methods of finding it when the vessel is heeled.

The transverse C.B. when the vessel is heeled can be calculated, but this is a very complicated and laborious process, and Blom's method, which is a purely mechanical method, is recommended.

The shape of the underwater portions of the sections, taken up to the waterline at the desired angle of heel, is pricked off on to thin cardboard from a tracing of the body plan. These sections are then cut out with scissors and pasted lightly together in their correct relative positions. Do not use more paste than necessary as the weight may interfere with the balancing. The common centre of gravity has now to be determined. This is done by suspending the bunch of sections from two or more points at the edge of the card and noting where the plumb lines from the points of suspension intersect. Points should be selected

so that the plumb lines do not intersect at too acute an angle so as to get a good sharp cut. The point of intersection is the C.B. and its distance from the centreline can be measured in a direction parallel with the heeled waterline.

If it is desired to find the C.B. of a single section it is done in a similar way.

Another method of ascertaining the C.B. is by the use of an instrument called an "Integrator," but as model yacht designers are very unlikely to possess, or have the use of, one of these instruments this need not be gone into here.

* * * *

We can next consider the Metacentre, but

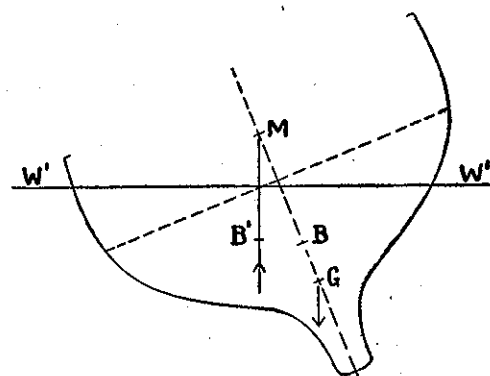


FIG. 37.

let us start with the forces that act on a vessel's hull. Buoyancy can be considered as a supporting force upholding the vessel, with its vertical up-thrust concentrated at the C.B. Gravity can be considered as a depressing force with its down-pull acting vertically downward through the C.G.

Now it is obvious that when a vessel is on an even keel, a line produced vertically upward through the C.B. coincides with the centreline. Directly she heels, the C.B. will automatically shift over to leeward. At the same time, since the in-wedge is larger than the out-wedge and the vessel does not increase her actual displacement, she rises bodily in the water until the in-wedge and out-wedge are exactly equal. This is shown in Fig. 37, where W' represents

METACENTRIC CALCULATIONS

the heeled waterline, G the C.G., B the upright C.B., and B' the heeled C.B. If a vertical line is produced upward through B' it meets the centreline (i.e., the original vertical through B) at M, which is the Metacentre.

As the C.B. varies for every different angle of heel, every vessel has innumerable metacentres to correspond. It is, however, possible to design a hull of a shape such that the metacentres coincide for all normal angles of heel. Such a hull is called a "Metacentroid." There is no particular virtue in this, however, and, as will be seen later, it is likely to be more detrimental than otherwise for a racing yacht at all events.

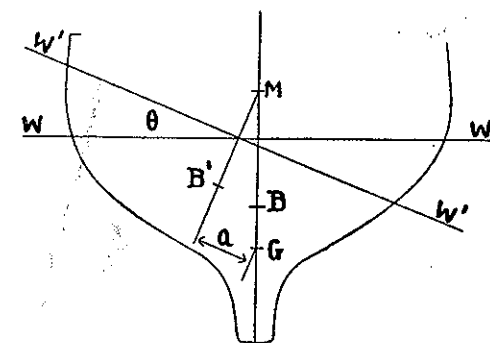


FIG. 38.

For small angles of heel (up to about 10 degrees) the height of the Metacentre (M/C) remains practically constant. It can be calculated by the following formula:—

The height of the M/C above the C.B. is equal to the moment of inertia of the waterline plane about the centreline divided by the volume of the displacement, or

$$BM = \frac{I}{V}$$

This entails the ability to calculate the Moment of Inertia of the waterline plane about the centreline, so we must digress to explain how this is done.

To obtain the Moment of Inertia of a waterline plane about its longitudinal axis, measure the half-breadths at each section station, cube these and apply the Trapezoidal

Rule to the cubes, the result being multiplied by $\frac{1}{3}$. If the drawing is not full-size the half-breadth widths should be scaled up first. Otherwise the sum of the cubes must be multiplied by the cube of the inverted scale (i.e., if the drawing is half-size the sum must be multiplied by 8).

As an example of this calculation, our 36-in. model works out:—

Sect. Nos.	Half-Breadths.	Cube.
1	0.00	0.00
2	1.50	3.37
3	2.86	23.39
4	3.78	54.01
5	4.27	77.85
6	4.30	79.51
7	3.92	60.24
8	3.02	27.54
9	0.00	0.00
		<u>325.91</u>
Less $\frac{1}{3}$ sum of first and last ordinates . . .		0.00
		<u>325.91</u>
Multiplied by Station Interval . . .		3.5
		<u>162.95</u>
		<u>977.73</u>
		<u>1140.68</u>

$$\text{Moment of Inertia} = 1140.68 \times \frac{1}{3} = 760$$

We have found the Volume of Displacement of this boat to be 280.7 cu. in., so:—

$$BM = \frac{760}{280.7} = 2.71 \text{ in.}$$

As we have found the C.B. is 1.35 in. below L.W.L., the M/C is $2.71 - 1.35 = 1.36$ in. above L.W.L.

In Fig. 38 we have the usual M/C diagram in which θ = the angle of heel and a (which is the distance between B' and G in a direction parallel to the heeled waterline) is the Righting Arm. The Righting Moment of the boat is Displacement multiplied by Righting Arm.

The M/C Height is GM (i.e., Height of M/C above C.G.).

The actual formula for calculation of the Righting Arm is:—

$$GM \sin \theta = \text{Righting Arm,}$$

and that for Stability:—

$$D \times GM \sin \theta = \text{Stability.}$$

This is not a difficult calculation, and something will be said about its uses in a later chapter.

Another way of finding the Righting Arm is to find the C.B. of the hull in a heeled position by Blom's method and plot it and measure.

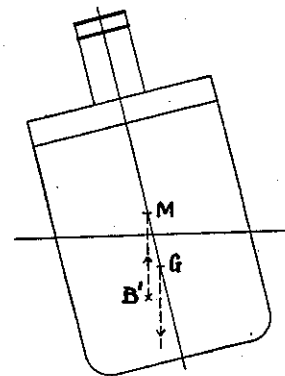


FIG. 39.—VESSEL IN CONDITION OF STABLE EQUILIBRIUM.

Obviously the greater the distance the C.G. is below the M/C the greater will be the stability of the vessel for any given angle of heel. It is also evident that two considerations enter into the stability of the hull—its form as affecting the position of the C.B., and the weight and its disposition as affecting the position of the C.G.

As long as the C.G. is below the M/C the stability is positive and the hull will return to an upright position. When the C.G. coincides with the M/C the stability is said to be neutral, but when the C.G. is above the M/C the stability is negative and the vessel will capsize. It is not necessary for the C.G. to be below the C.B. for her to be stable, but it must always be lower than the M/C or she becomes unstable. In a sailing vessel it is

desirable to have the C.G. as low as possible to have a powerful righting moment and thus enable the vessel to carry her sail.

In a steamer which has not the steadying influence of sails, the vessel is apt to have a jerky motion if the C.G. is too low. A steamer is shown rolling heavily in Fig. 39, and she is assumed to have a heavy cargo below hatches and a light deck cargo. The force of buoyancy thrusting upward through B' and the force of gravity pulling downward through G , both combine to give the vessel a strong righting moment. In Fig. 40 the same steamer is shown, but this time she has a heavy deck cargo and a light cargo below hatches. The

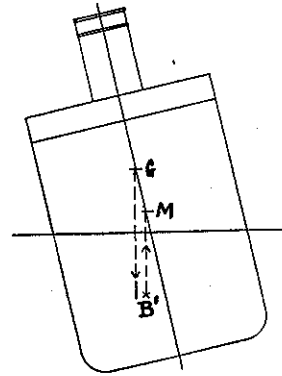


FIG. 40.—VESSEL IN CONDITION OF UNSTABLE EQUILIBRIUM.

C.G. is now above the M/C, and the force of buoyancy and the force of gravity are combining to capsize her. While this instance does not concern the model yacht designer, it is included to enable him to get a grasp of the whole principle of stability and the M/C.

It will have been noticed that when we compared the fore-and-aft positions of the C.B. for the hull on an even keel and heeled, no allowance was made for the hull rising until the in- and out-wedges were equal, as shown in the M/C diagram above. Fortunately for the designer, when a vessel is sailing she tends to settle deeper in the water, due partly to the downthrust of the wind in her sails and partly to the arrangement of displacement in the design. It is, therefore, sufficiently near if we consider the heeled L.W.L.

as passing through the intersection of the upright L.W.L. and the centreline.

Another point is that in making these tests the extreme effective angle of heel (varying with the yacht herself) is taken for purposes of comparison with the upright hull, since if the hull is balanced upright, and at this extreme angle of heel, she will be balanced at all intermediate angles.

If the reader will take the trouble to draw a few sections of different types and take out their M/C at various angles of heel, he will find the M/C a very useful and reliable guide as to performance. It will immediately be apparent that beam has an immense influence on the position of the M/C. For instance, the beamy scow has a very high M/C at low angles of heel, but once a certain angle is exceeded her M/C begins to fall very rapidly. This indicates great initial stability, but increasing tenderness once a certain angle of heel is exceeded. On the other hand, a boat with a deeper, narrower section has a comparatively low M/C at small angle of heel, but the M/C rises rapidly as the angle of heel increases. This indicates that the boat will heel readily to her sailing angle in light breezes, and become increasingly stiff as her angle of heel increases. The extreme instance of this type is the "plank-on-edge," and though it is not desirable to go to this extreme for many reasons, it is a distinct advantage for a racing yacht to have a low initial stability that increases rapidly as the heel increases. In this way a yacht readily lengthens her sailing waterline in light winds and yet has plenty of sail-carrying power without any tendency to rise on her bilges.

As previously mentioned, a Metacentroid is a vessel with a constant Metacentric Height at all normal angles of heel, and it is possible to design a Metacentroid with either a low M/C or a high M/C. Probably, for reasons of stability, she would be designed with a high M/C, and such a boat would be at a great disadvantage in light winds, when opposed to a well-designed hull that heels readily under these conditions to her sailing angle, and yet has plenty of power to carry her sail in heavier winds. This desideratum can

only be attained by designing a hull in which the M/C alters its height to suit prevailing conditions. This applies to racing yachts particularly, but as cruisers Metacentroids might be suitable, particularly in types which are designed to sail as upright as possible and not to be pressed to extreme angles of heel.

* * * *

Much has been heard in recent years about Admiral A. Turner's system of balancing a hull, but very few yachtsmen or model yachtsmen have really understood it. This, we believe, is due to the fact that it has been described as the "M/C Shelf" System, whereas it is simply a method of checking the distribution of displacement in the hull by balancing Moments of Buoyancy about the Mean Axis of Buoyancy. The *modus operandi* is as follows:—

Find the C.B. for each individual section of the boat for the full L.W.L. length, when heeled to the maximum effective sailing angle. Also find the transverse C.B. for the whole boat at the same angle. Do this by Blom's method, as previously described.

Through the C.B. of the boat draw a line parallel to the fore-and-aft centreline. This is the vessel's Mean Axis of Buoyancy for this angle of heel. Next plot the individual section Centres of Buoyancy in their correct positions relative to the Mean Axis of Buoyancy. These may fall along the Mean Axis of Buoyancy, or to windward or leeward of it. A line is run through the section Centres of Buoyancy, and this is the actual Axis of Buoyancy of the boat.

If the Centres of Buoyancy lie along the Mean Axis of Buoyancy, the actual Axis of Buoyancy will be a straight line coinciding with the Mean Axis of Buoyancy, and the balance is satisfied. This will be obvious when it is understood how the Moments of Buoyancy are balanced, since when the Axis of Buoyancy coincides with the Mean Axis of Buoyancy, the arm of the Moments of Buoyancy of the Sections is 0, and consequently all the Moments of Buoyancy also equal 0.

It is not necessary for the Axis of Buoyancy to coincide with the Mean Axis of Buoyancy, and a hull can also be balanced when the

Axis of Buoyancy is curved, provided it is regularly disposed about the Mean Axis of Buoyancy, and the Moments of Buoyancy are correctly balanced.

It should be observed that in a racing yacht with a bulky keel the Centres of Buoyancy of the sections in the centre of the boat in the way of the keel will lie to windward of the Mean Axis of Buoyancy. In a boat with a

is plotted about the Mean Axis of Buoyancy, the parts to windward must of necessity equal those to leeward (*i.e.*, the areas $a + c = b$, where a represents the fore-body, c the after-body, and b the middle-body), and if the fore-body balances the after-body, the area $a =$ the area c . The whole idea of the system is that in a balanced boat the Moments of Buoyancy of the fore-body must fall on the same side of the

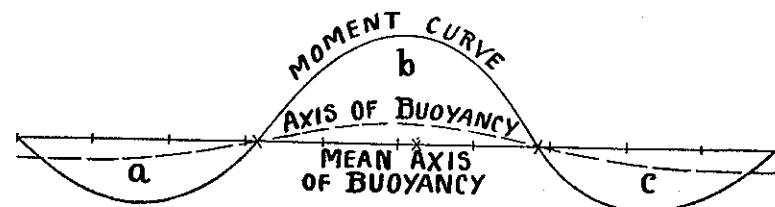


FIG. 41 (a). MOMENTS OF BUOYANCY CORRECTLY BALANCED.

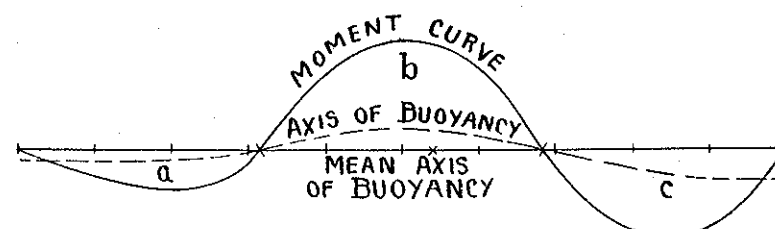


FIG. 41 (b). MOMENTS OF BUOYANCY INCORRECTLY BALANCED.

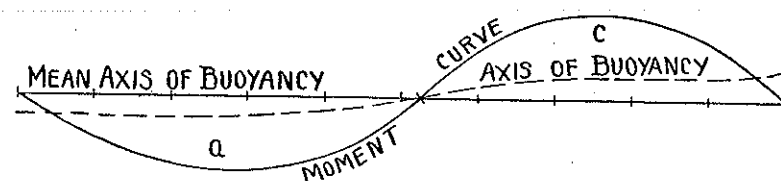


FIG. 41 (c). MOMENTS OF BUOYANCY VERY BADLY BALANCED.

plate keel or a cruiser with a small keel, the reverse will be the case. The ends of the boat should *both* fall on the opposite side of the Mean Axis of Buoyancy to the centre of the boat.

If the reader will refer to Fig. 41 (a) he will see the Axis of Buoyancy shown as a broken line. Moments of Buoyancy are taken (Area of Section multiplied by difference between C.B. of section and Mean Axis of Buoyancy), and plotted. Now since the Curve of Moments

Mean Axis of Buoyancy as those of the after-body and be equal to them.

It should be added that in order to make the theory clear, Fig. 41 (a) shows a theoretical Axis of Buoyancy and Curve of Moments rather than those of an actual yacht, since those of actual yachts do not usually exactly agree with the absolute ideal, and though they may be near enough for all practical purposes of balance, theoretical curves make better examples for illustrating the theory.

Now Fig. 41 (a) shows the Moments of Buoyancy correctly balanced, but in Fig. 41 (b) and (c) we have common forms of incorrect balance. In Fig. 41 (b), although both ends of the boat, a and c , fall on the same side of the Mean Axis of Buoyancy, they are unequal in area. In such a boat the ends need re-designing, a being increased and c decreased. This may necessitate alteration of areas of the sections, or more likely in this case alteration of beam, or both. It should be added that though it is equally possible for a to be greater than c , the fault is not so common.

In Fig. 41 (c) still more serious faults are revealed, since the two ends of the boat are on opposite sides of the Mean Axis of Buoyancy. Such a boat requires complete re-designing. The faults shown in Fig. 41 (b) or (c) will have obvious steering effects.

It is sometimes suggested that to cure faults of this kind the keel should be shifted forward or aft, or made thinner or thicker. If a reasonable keel has been designed, it is strongly recommended that this be left alone and attention be given to the design of the canoe body.

This method of balance is supplementary to the usual checks on the fore-and-aft positions of the upright and heeled Centres of Buoyancy, which must *on no account* be omitted. The routine inspection of the upright and heeled Curves of Areas must also be carried out. As a matter of fact a boat that gives satisfactory results when tested by these two methods, is unlikely to show up badly by

Admiral Turner's further test of the "M/C Shelf."

This system of balance has been accepted by some well-known designers and rejected by others. Whether it is a correct method to test a vessel's static balance or not, and whether a static balance of this kind gives any useful indication of the vessel's dynamic balance, or whether the radius of gyration about the C.B. should be considered, are points upon which divergent opinions are held. From the way the theory has been presented, the reader will be able to understand it and the reasoning that prompted Admiral Turner to formulate it, and therefore to form his own estimate of its value.

Boats designed specially to comply with this system of balance have done very well in open competition, but, on the other hand, any reasonably well designed yacht complies pretty closely with its requirements whether designed with this intention or not.

It is, however, certain that this system of balance is not a panacea for all evils, and a yacht's behaviour is governed by many different things, all of which must receive due consideration by the designer.

Finally it should be said that balance in itself, however perfect, will not make a prize-winner, and a yacht to be fast must also be designed with due regard to the factors that make for speed. On the other hand, especially in a model, absence of balance will make a boat uncontrollable, and prevent her being successful.

CHAPTER VIII

Designing the Sail-plan. General Considerations. Selection of Rig. Proportions of Headsail to Aftersail and Height to Breadth. Calculation of C.E. and Position of Rig over Hull.

IN designing a sail-plan, the first things to determine are the rig and area that are to be adopted. In full-size yachts the rig is mainly determined by questions of utility in consideration of the work that the yacht is expected to perform. For example, in a cruising yacht, the considerations will be the number of hands available and whether the vessel is required for coastal work or ocean voyages. It is obvious that the more any given area is subdivided, the more easily can each sail be handled. Further, if the yacht is required for ocean cruising, any reduction in weight of spars will tend towards more comfortable conditions for the crew. If, however, the yacht under consideration is a racer, the sole consideration must be to make the most efficient use of the sail area that she is permitted to carry under her class.

Recent discoveries in aerodynamics have shown that a sail set on a wire stay is the most efficient aerofoil for any given area, provided that the stay is kept rigid and the sail is correctly sheeted. It is, however, essential to have a mast to support the sails, and the triangular mainsail is the most efficient form of mainsail.

Again, if the length of masthead required to set a gaffsail is taken into consideration, area for area, the triangular mainsail requires less length of spars to set it than any other. Obviously also the gear required for a triangular sail is less than that required to set an ordinary gaff mainsail.

The question of area from the point of view of handling does not trouble the model yachtsman, but, on the other hand, in order to gain efficiency during races he must reduce his gear to a minimum. It might be suggested that this, coupled with the fact that the sail would not be divided, would point to the adoption of the una rig. Actually, however, a single-sail rig is most difficult to balance in a

model, and, further, the single sail does not give the greatest efficiency.

Recent experiments in aerodynamics have shown that two aerofoils working in conjunction are infinitely superior to a single aerofoil of their combined area. The principle involved is that of the overlapping wings of insects, and there is also a less pronounced form in the wing of the eagle. It would require another book to deal fully with this subject, and those who wish to probe the matter further are advised to obtain Dr. Manfred Curry's two books on the aerodynamics of yacht sails.

The best rig, therefore, to adopt for a model yacht is the Bermuda sloop with a single jib and mainsail. In designing a racing model under a rule that embodies both hull and sail measurements, the question of the proportion of hull to sail is one that requires the closest consideration. This matter has been previously referred to, and the best guide for the novice is to study the proportions of successful boats under the class to which he is designing. This is not a very scientific method of tackling the problem, but it is certainly the best for the amateur designer to follow.

Having decided upon the rig and area, the next considerations are the proportion of headsail to aftersail, and the proportion of height to breadth in each of these sails.

When the position of the keel appendage was being discussed, reference was made to the shift of the centre of pressure towards the leading edge, as exemplified by the falling leaf. In deciding the proportions of sails this principle must also be borne in mind. As the wind speed across the sails increases, the tendency is for the pressure to become more concentrated at the leading edge, and this has the effect of dragging the centre of pressure forward. This forward travel will be in proportion to the breadth of each sail, and their

ON SAIL-PLAN DESIGN

combined centre of pressure will also be influenced by their relative areas. If, therefore, an excessive amount of sail is placed forward of the mast, the forward travel of the centre of pressure will be so great that the boat's head is forced off the wind as the latter increases in strength, and she will refuse to point up. A certain amount of forward travel is necessary to keep the boat full and bye.

However perfect a hull is, there is just one sail-plan and position for it over the hull that will give the best results. This differs with each boat, but average modern sail-plans have from $27\frac{1}{2}$ to 35 per cent. of headsail. This is actual area, not sail area as measured for rating purposes. A little experiment may, however, prove necessary before the best combination is arrived at.

With regard to the aspect ratio (proportion of height to breadth) of sails, wind tunnel tests show that for windward work a proportion of 9 to 1 gives the best results, and dead before the wind a proportion of 1 to 1. It would appear that the best proportion for all-round work lies about half-way between. At the same time this data must be regarded with the greatest suspicion when it comes to its application to yacht sails. These tests were made with aeroplane wings, and there is an essential difference between a rigid aerofoil like a wing and a flexible aerofoil like a yacht's sails.

Actually it has been found that the back of the sail does more work than the front, and it has been proved that the old saying that "an inch in the luff is worth two in the leach (or foot)" is well founded, but there are limits as to how far this may be carried with success.

When a yacht is close-hauled, what actually happens is that the wind impinges upon the luff of the sail first and spills away across the sail, finally escaping at the leach. This escaping wind from the luff has its free passage across the sail impeded by the wind which strikes upon the after-part of the sail, with the result that a choke occurs and pressure develops. The highest pressure is naturally at the luff. The amount of this choke, and the pressure produced thereby, therefore, entirely depends on the efficiency of the after-part of

the sail. Now this area of maximum pressure is more or less proportionate to the width of the sail, and it follows that if the total width of the sail is unduly reduced, the width of the most efficient part will likewise be reduced, and its efficiency per square inch of surface will also suffer by reduction in pressure.

Another consideration which has to be borne in mind in connection with narrow sails is the question of the spiral flow that manifests itself to a certain extent in all sails, but increases to an excessive extent when the sail is too high in proportion to the width, with the result that the sail is very difficult to control and is consequently ineffective, especially off the wind. A particularly difficult sail to control in this respect is a schooner's foresail, which is a high narrow sail, and unless great precautions are taken the gaff will swing outboard. The skipper is then faced with the dilemma that he must either have his sail so closely sheeted that the lower part is too close-hauled to be efficient, or ease off and trim the lower part, with the result that the upper part spills.

A further difficulty arises from the fact that the length of the keel appendage and the base of the sail-plan are directly related, so that a long keel requires a wide base to the sail-plan and a short keel a narrow base. In a model, if the keel appendage and base of the sail-plan are too long, the boat will be sluggish and not pay off quickly, whilst if they are too short the boat will be tricky and difficult to control. As in all things connected with yacht design, the happy medium is the only correct course, as any good feature will lose its virtue if carried to excess.

Whilst the headsail is not such a difficult problem from the point of view of sheeting, if this sail is designed too high and narrow the same problem will arise in getting the head of the sail to draw properly. If the jib is designed in such a manner that the sail has to be strapped down in order to get the head of the sail to draw properly, the lower part of the sail will not be able to do its work efficiently. Primarily a jib is a lifting sail, but if it is too closely sheeted it becomes a depressing sail. A further difficulty experienced with models is

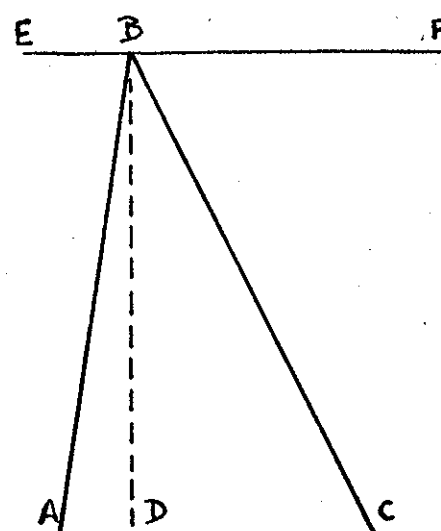


Diagram A.

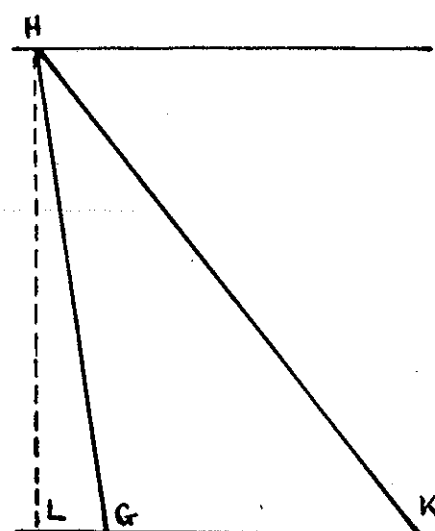


Diagram B.

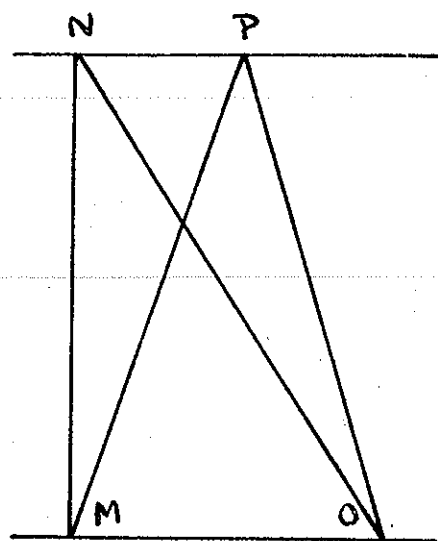


Diagram C.

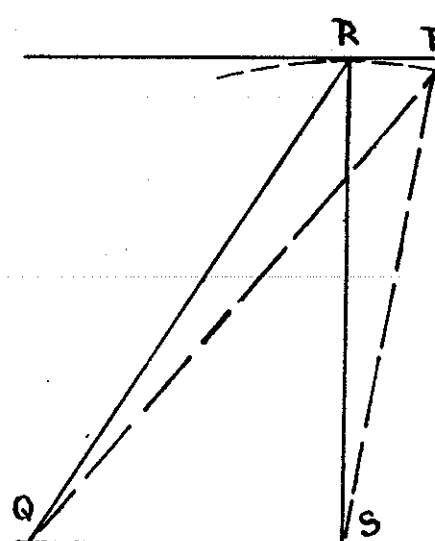


Diagram D.

FIG. 42.

that the jib-sheet works on a horse, and if it is too tightly sheeted, it will not travel across when the boat is tacked.

For a boat as small as the little model under consideration it might not be considered advisable to go to the extreme limits of height, and the dimensions given on the sail-plan were accordingly selected as being suitable.

Before the sail-plan can be designed, it is necessary to know how to calculate the area and find the Centre of Effort (C.E.).

For the purposes of calculating sail area, all that is needed is to be able to calculate the area of a triangle, as quadrilateral sails are divided into two triangles by a diagonal and calculated as two triangles. There are also one or two elementary geometrical facts that it is useful to remember in this connection.

The area of a triangle is the base multiplied by the vertical height divided by 2. In Fig. 42, Diagram A, to find the area of the triangle ABC, the base AC is multiplied by the vertical height AD and the result divided by 2. The perpendicular AD is, of course, the vertical height.

In Diagram B is shown a triangle where the perpendicular HL meets the base KG produced. The area of the triangle GHK is, therefore, GK multiplied by HL divided by 2. Now AC equals GK and BD equals HL, and, consequently, these two triangles are equal in area. Similarly, any two triangles on the same base and between the same parallel lines, as MNO and MPO in Diagram C, are likewise equal.

In this connection it has sometimes been asserted that under the I.Y.R.U. system of sail measurement the area of the fore triangle is increased by raking the mast, but a glance at Diagram D will show that this is not so, and that raking the mast decreased the actual area.

In the case of a jib or triangular mainsail, of which it is desired to find the area, the usual procedure is to take the luff of the sail as representing the base of the triangle and the clew as its apex.

Turning to Fig. 43 to calculate the sail area :

Jib—

$$32.5 \times 10.5 \div 2 = 170.625 \text{ sq. in.} = \text{say } 171 \text{ sq. in.}$$

Mainsail—

$$45.0 \times 21.0 \div 2 = 472.5 \text{ sq. in.} = \text{say } 473 \text{ sq. in.}$$

644 „

Before dealing with the method of finding the area of a quadrilateral sail, there is one point in connection with headsail areas that might be mentioned. The little 36-in. boat, which has been used as an example throughout these chapters on Designing, is to the M.Y.A. 36-in. Restricted Class. Sail area does not enter into the rule and is accordingly unrestricted. Sail area is, however, a factor in all other measurement rules, and the headsails are usually measured on the area of the fore triangle instead of the actual area of the headsails.

As was explained in the chapters on Rating Rules, this is done by measuring from the fore side of the mast to the point where the line of the luff of the foremost headsail would meet the deck (or bowsprit as the case may be), and up the fore side of the mast to the point of attachment of the halliards of the foremost headsail. These two factors are multiplied together and the result divided by 2. Eighty-five per cent. of the area so found is taken as being the headsail area in calculating the total sail area for rating. Many model yachtsmen have the idea that this gives additional unmeasured area, and that very large headsails give an advantage on this score. In order to see how far this is justified, we will work out the headsail area of our 36-in. model by this method. The base of the fore triangle measures 12.75 and the hoist is 33.5. The rated area would then be :

$$(33.5 \times 12.75) \div 2 \times 0.85 = 213.5625 \times 0.85 = 181.528 \text{ sq. in.} = 182 \text{ sq. in. (approx.).}$$

By actual measurement our jib was found to be 171 sq. in., so that actually speaking there is a slight loss in measurement rather than gain. In practice the 15 per cent. deduction is quite a fair and reasonable way to estimate the space in the fore triangle that is not actually filled with sail. This method of measurement, moreover, in real yachts permits the use of balloon jibs

SAIL AREA.

JIB	171
MAINSAIL	473
	<u>644</u>

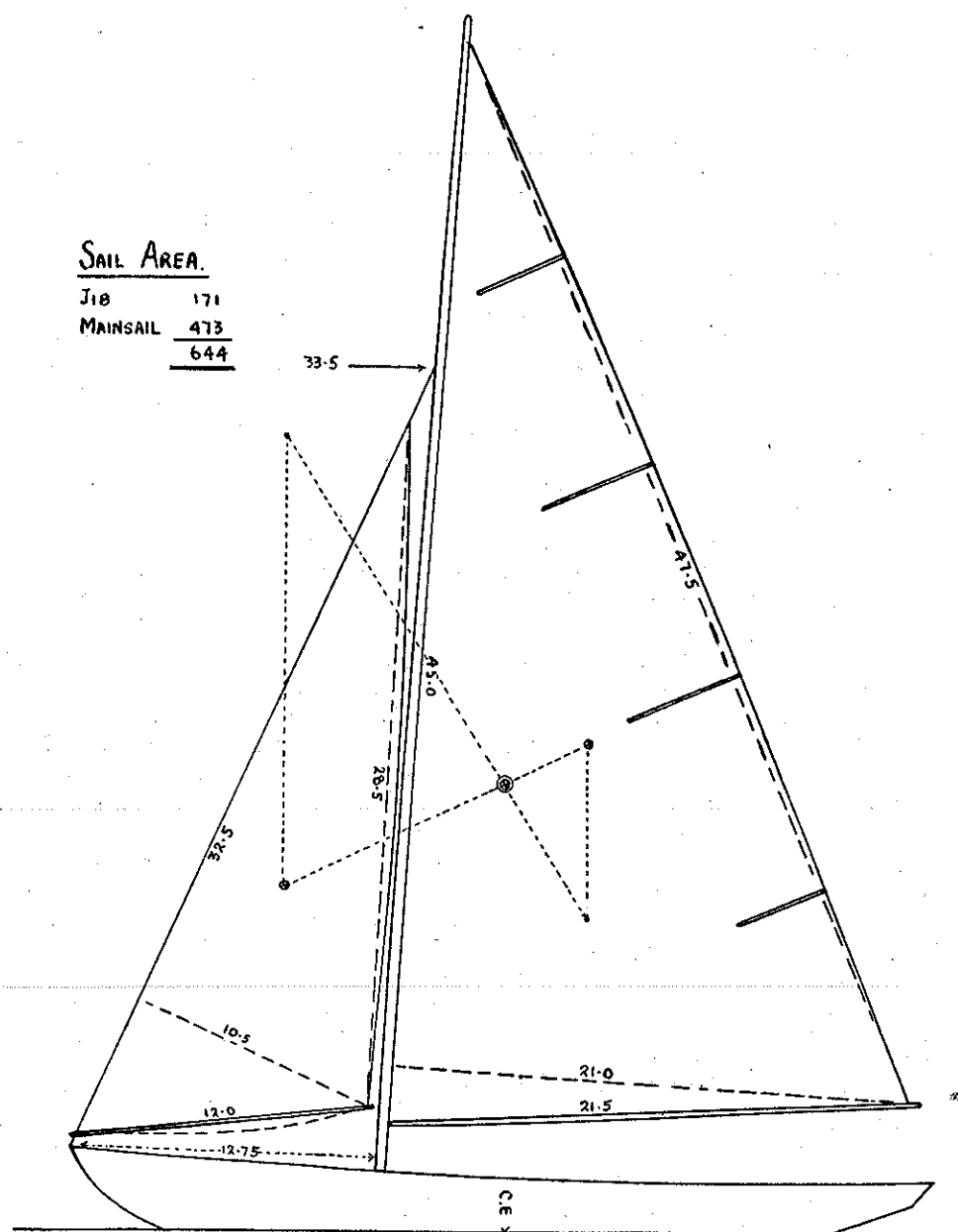


FIG. 43.—SAIL PLAN OF 36-INCH MODEL.

CALCULATION OF AREA OF GAFF MAINSAIL

and takes care of the spinnaker measurements.

For rating purposes the hoist of the spinnaker is measured in the same manner as that of the jib, but the base is taken from the fore-side of mast to the tack of sail measured along the top of the boom. Now from the simple geometrical facts mentioned above, it is obvious that the area of this is unaffected by the height above deck at which the boom is carried, provided that it is the same length and

lateral ABCD and the diagonal from peak to tack by AC, which divides the figure into two triangles. It is customary to use this diagonal as the base of each of the triangles. Then the area of the quadrilateral will be:

$$(AC \times BE \div 2) + (AC \times DF \div 2).$$

Substituting the actual values from the figure, we get:

$$(43 \times 8 \div 2) + (43 \times 22 \div 2) = 172 + 473 = 645 \text{ sq. in.}$$

The leach of the sail has hitherto been con-

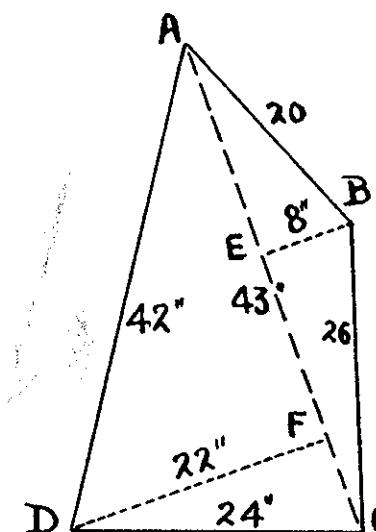


Diagram A.

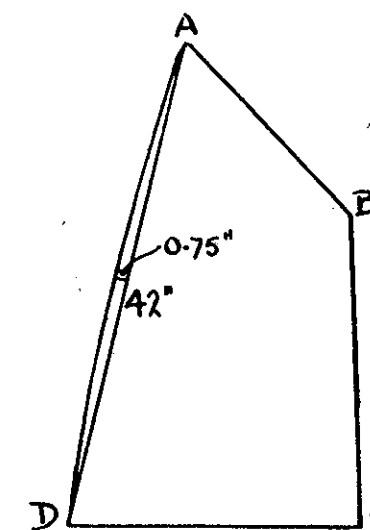


Diagram B.

FIG. 44.

kept exactly at right angles to the mast. But if the boom is canted up or down, the area is decreased accordingly.

Turning to the calculation of quadrilateral sails, these comprise "squaresails" and gaffsails. The squaresails, being rectangular, present no difficulty in calculation, as it is only necessary to multiply the height by the breadth.

In the case of a gaffsail or spritsail, the sides are not equal, and the method employed is to divide the figure by a diagonal from the peak to the tack, as in Fig. 44, Diagram A. In this the sail is represented by the quadri-

lateral ABCD and the diagonal from peak to tack by AC, which divides the figure into two triangles. It is customary to use this diagonal as the base of each of the triangles. Then the area of the quadrilateral will be:

$$(AC \times BE \div 2) + (AC \times DF \div 2).$$

Substituting the actual values from the figure, we get:

$$(43 \times 8 \div 2) + (43 \times 22 \div 2) = 172 + 473 = 645 \text{ sq. in.}$$

The leach of the sail has hitherto been con-

MODEL SAILING CRAFT

(usually known as the "roach"), the area of the sail is first calculated in the ordinary way as if the leach was straight, and then the area of the roach is taken separately and added.

multiplied by two-thirds of the width of the bow.

In Diagram B the same gaffsail is shown again, but with a roach added to the leach.

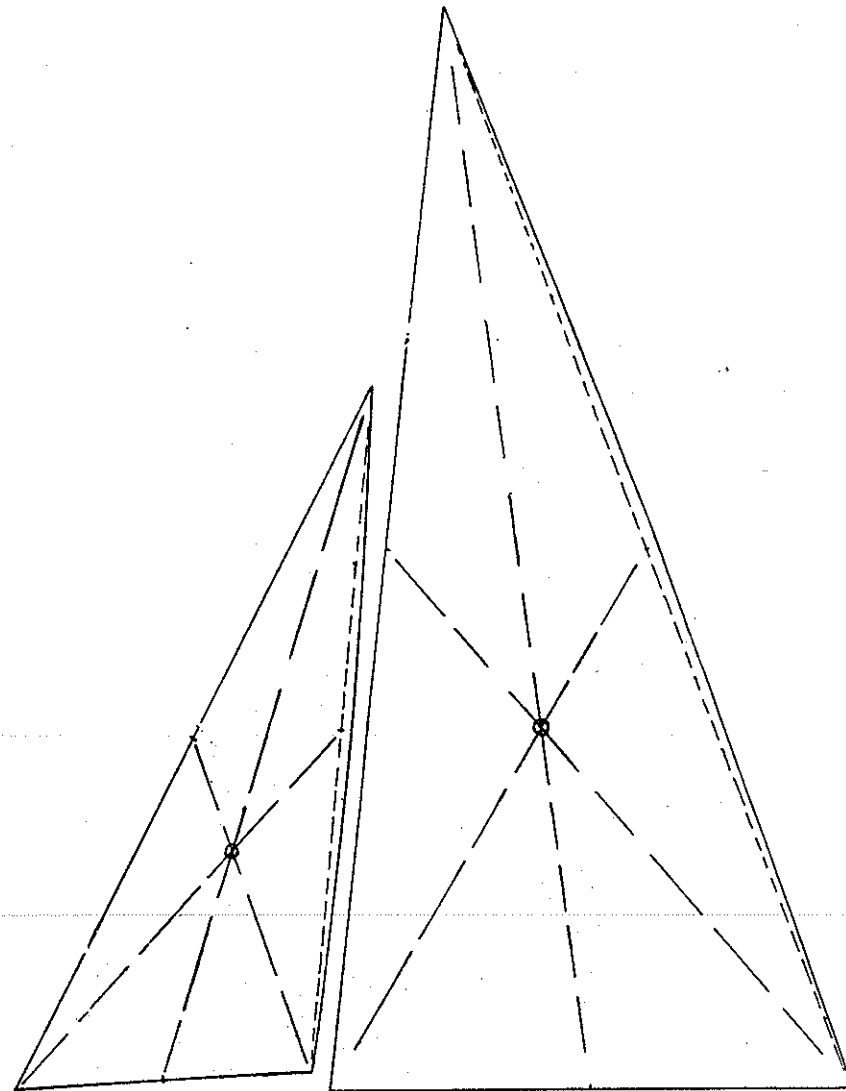


FIG. 45.—THE SAIL-PLAN OF 36-INCH MODEL SHOWING C.E. OF EACH SAIL FOUND SEPARATELY.

To get the area of the roach the leach is first measured as if it was a straight line, and then the greatest width of the bow beyond this is taken. The base of the figure is then

The straight measurement of the leach is 42 in., and the greatest width of the roach is 0.75 in. The area of the roach is therefore:
 $42 \times (0.75 \times \frac{2}{3}) = 42 \times 0.5 = 21 \text{ sq. in.}$

FINDING CENTRE OF EFFORT

As the area of the sail without the roach was 645 sq. in., the total area will be $645 + 21 = 666 \text{ sq. in.}$

Having explained the method of finding the area of various types of sails, the next thing is to find the Centres of Effort of single sails and finally the combined C.E. of the whole sail-plan.

Now the Centre of Effort of a sail is calculated as if it were the centre of gravity of a plane surface. In the case of a triangular sail,

two triangles ABC and ADC. By the method already explained (viz., bisecting each side and joining to the opposite angle), the centre of each of these triangles is found at E and F respectively. The next step is to join the throat B to the clew D by the line BD, dividing the sail into the triangles ABD and BCD. The centres of these are similarly found at G and H (see Diagram B). The centres EF are joined, also GH. The lines EF and GH intersect at K (see Diagram C). This is the

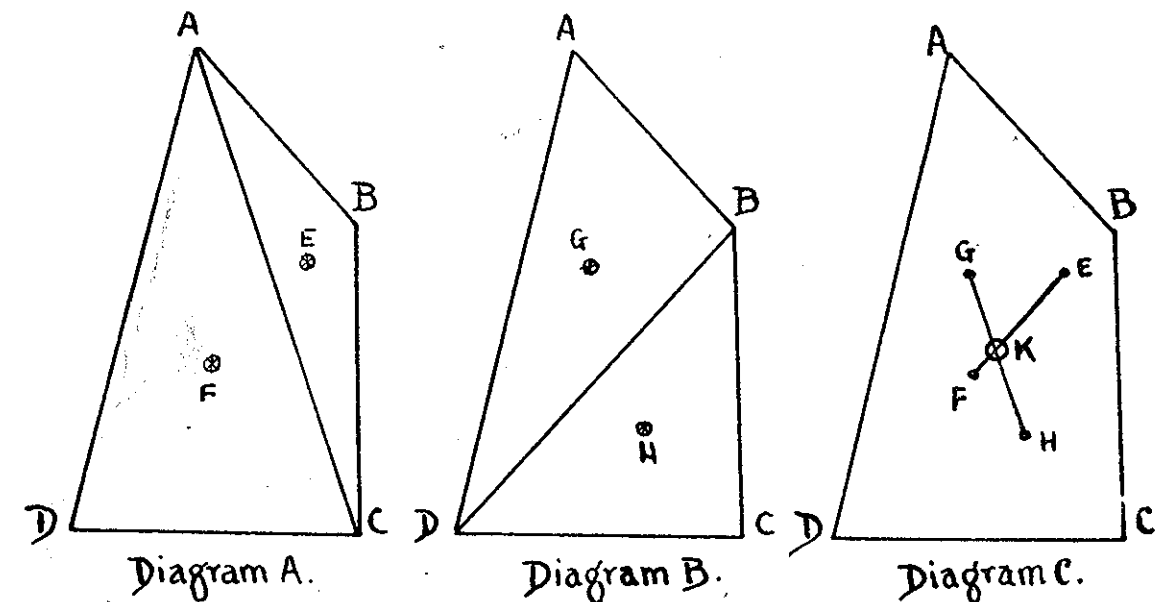


FIG. 46.—FINDING C.E. OF A GAFF MAINSAIL.

whether a headsail or a Bermudian mainsail, this is found by bisecting each side and joining the point so found to the opposite angle. The lines so drawn intersect at a point which is the C.E. of the sail concerned. In Fig. 45 the jib and mainsail of our little 36-in. model are shown with their centres found in this manner, and the C.E. of any triangular sail can be found in a similar fashion.

When a four-sided gaffsail is under consideration, rather different methods have to be used. In Fig. 46, Diagram A, the sail ABCD is shown. The peak A is joined to the tack C by the line AC, which divides the figure into

C.E. of the whole sail. The reason of this is that the combined C.E. of the triangle ABC and ACD must lie on the line EF, whilst that of the triangles ABD and BCD must lie on the line GH. The only spot common to both is their intersection at K.

Having found the Centre of Effort of each sail, the next thing to do is to find the combined C.E. of the whole sail-plan. A yacht with only two sails presents a much simpler problem in this respect than one that has three or more sails.

Taking the sail-plan of our little 36-in. yacht, of which the centres of effort of jib and

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mainsail have already been found, it is obvious that the combined centre must lie along a line joining the two centres. The area of the jib is 171 sq. in., and that of the mainsail 473 sq. in., and the centre of the jib is 14 in. distant from that of the mainsail. The combined C.E. will therefore be on the line joining the centres of the two sails at a distance from the centre of the mainsail of:

$$\frac{14 \times 171}{644} = 3.72 \text{ in. (approx.)}$$

The usual method of calculating this is by taking moments from a suitable position. Usually this is taken from the foremost part (the tack) of the foremost headsail. In the case of this boat the C.E. jib is 8.75 in. abaft this point and the C.E. mainsail 21.25 in. The calculation will, therefore, be:

$$\frac{(\text{Area Jib} \times \text{distance}) + (\text{Area Mainsail} \times \text{distance})}{\text{Total Sail Area}}$$

Substituting the actual figures:

$$\frac{(171 \times 8.75) + (473 \times 21.25)}{644} = \frac{1496.25 + 10041.25}{644}$$

= 17.88 in. abaft tack of foremost headsail.

It will be seen that this has merely given us the fore-and-aft position of the C.E., if the height of this is also required a similar calculation must be worked, taking the heights of the C.E. of each sail above L.W.L.

In the case of a two-sailed vessel, a very simple way of ascertaining the exact position of the C.E. after finding the fore-and-aft position in this manner is to join the centres of the two sails by a line. Then at the fore-and-aft position of the combined C.E. erect a perpendicular to the L.W.L., and where it cuts the line joining the centres is the exact C.E.

Another method of ascertaining the C.E. of the whole sail-plan is to plot it graphically. This is shown in the sail-plan of our little yacht (see Fig. 43). The two centres are joined by a line. From the centre of the jib

draw a vertical line carrying it above this centre for a distance representing the area of the mainsail (using any convenient unit). From the centre of the mainsail draw another vertical line extending below it for a distance equivalent to the area of the jib (on the same scale). Join the ends of these verticals, and the point of intersection of the line joining them with the line that joins the two centres is the C.E.

So far only craft with two sails have been dealt with, but when three or more sailed craft have to be dealt with the methods are just the same.

Take as an example a ketch with jib, staysail, mainsail, main topsail, mizzen and mizzen topsail. To work this by moments, find the C.E. of each separate sail and measure its distance abaft the tack of the foremost headsail (the jib).

Then: (Area Jib $\times$ distance) + (Area Staysail $\times$ distance) + (Area Mainsail $\times$ distance) + (Area Main Topsail $\times$ distance) + (Area Mizzen $\times$ distance) + (Area Mizzen Topsail $\times$ distance) gives the sum of the moments, and this is divided by the total sail area. The result gives the distance abaft the tack of the jib for the combined C.E. of the sail-plan.

Another method which is only an application of the method of getting the C.E. by plotting it would be to take the sails in twos. For instance, the C.E. jib and C.E. staysail might be taken first and the C.E. headsails found. After that the combined C.E. of the mainsail and main topsail could be found, and also that of the mizzen and mizzen topsail. The centre of the headsails could then be combined with that of the mainsail and main topsail. Finally their combined C.E. might be taken with that of the mizzen and mizzen-topsail, thus obtaining the C.E. of the whole sail-plan.

Unless it is desired to work stability calculations, all that is really required is the fore-and-aft position of the C.E. Usually, under modern rules, there is no temptation to go to excess in sail area as to do so would entail such a sacrifice in hull dimensions, especially length,

POSITION OF SAIL-PLAN OVER HULL

that the resultant boat would be hopelessly outclassed by more moderate craft. The real reason for finding the C.E. is, therefore, to be able to arrange the sail-plan over the hull in the position that will give the best result. Our next consideration will, therefore, be where to put the sail-plan over the hull that has been designed.

In order that the boat shall pay off naturally and fill her sails, the C.E. of the sails will have to be placed forward of the boat's axis of turning. For this purpose the C.L.R. is always assumed to be that point, and the C.E. must, therefore, come forward of it. But, as has already been shown, both the C.E. and C.L.R. are moving points and, therefore, the only positions that can be compared with each other are the calculated C.E. and C.L.R. from which these centres start to move.

Although these points are used, actually speaking this comparison is deceptive. In the chapter on Keel Appendages it was shown that a change in the shape of profile would cause a boat to perform in a totally different way. For instance, a steeper angle to the leading edge of the keel would cause the C.L.R. to move forward more rapidly than an easier rake. Thus it might well happen that a change in profile that might not affect the position of the calculated C.L.R. would cause the boat to perform totally differently and require a different relative position of the sail-plan over the hull.

Therefore it must not be considered that there is any specific virtue in any set relative

positions for these points, and actually there is only one best position for the sail-plan over each hull, and that varies according to the sail-plan and the hull under consideration. In finding this position the model yachtsman is better off than his big brother, the yachtsman, as models are nowadays fitted with moving mast-steps with which fine adjustments of position and rake are possible without any structural alterations whatsoever.

It is usual to speak of the positions of the C.E. and C.L.R. in percentages of the L.W.L. These are usually measured from the forward waterline ending, but, as the ends of a L.W.L. are so easily snubbed back or drawn out in accordance with the demands of any particular rating rule, this again is entirely deceptive, and any percentages desired for comparison are best taken from the C.B., and in reality this is the actual pivot point about which the boat turns.

It must be emphasised that there is no specific virtue in any particular percentage as a guide to placing the centres. Further, if a boat gripes or pays off unduly, it must not be thought that it is necessarily the position or design of the sail-plan that is at fault, as it is just as likely that the trouble lies in the profile of the hull or the distribution of displacement. It is possible that this difficulty may be mitigated by moving the sail-plan, but that is not the same thing as avoiding the trouble. The young designer is, therefore, advised to take every care in his design to eliminate faults from his hull.

CHAPTER IX

Reduction of Effective Sail Area by Heeling. Stability Calculations. Wetted Surface Calculations. Building to Different Scales. Ratios for Use in Comparisons. Comparison of Speeds.

THE pressure of the wind on a vessel's sails can be mathematically resolved into lateral pressure, downward pressure and forward pressure. Much the largest of these is lateral pressure, and this is the force which causes a vessel to make leeway. Downward pressure is probably half as powerful as lateral pressure, and it is this down-thrust from the sails that enables a vessel to increase her displacement on heeling. Forward pressure is by far the smallest of these three components, and it is surprising how little of the wind's energy imparted to the sails is actually available for propulsion. When close-hauled it may be as little as between 5 and 10 per cent.

Of course the angle of the wind, both as regards trim and angle of heel, affects the proportion of energy available for propulsion, but assuming the foot of the sail to be trimmed at right angles to the wind, it is interesting to note how the angle of heel reduces the effective area. This is a very simple calculation, the formula being $S.A. \cos \theta$, θ being the angle of heel.

As an example of how this works out, a sail area of 1,000 sq. in. has been taken and worked out at a full range of angles of heel from 0° to 90°:—

0°	1,000 sq. in.	50°	642 sq. in.
5°	996 "	55°	573 "
10°	985 "	60°	500 "
15°	966 "	65°	422 "
20°	940 "	70°	342 "
25°	906 "	75°	258 "
30°	866 "	80°	174 "
35°	819 "	85°	87 "
40°	766 "	90°	0 "
45°	707 "		

When a sailing vessel is heeled, the righting moment of the hull exactly balances the heeling moment of the sails, and on this balance depends the angle to which she heels.

In considering whether a vessel can carry any proposed sail-plan, we, therefore, have to satisfy the equation:—

$$\text{Righting Moment of Hull} = \text{Heeling Moment of Sails.}$$

Now the Heeling Moment of the sails is found by multiplying the area of the sails by the height of the C.E. and the pressure of the wind. For full-sized yachts this is worked out in feet, but for models it can easily be done in inches. Some authorities take the height of the C.E. above the C.L.R., but others take it above L.W.L. It would appear to the authors of this book to be more logical than either to take it above the C.B. As regards the wind pressure, it is usual to assume a pressure of 1 lb. per sq. ft. (= 0.111 or $\frac{1}{9}$ oz. per sq. in.). The reduction of sail area by heeling can be ascertained as mentioned above. The Heeling Moment of the sails can be stated mathematically as:—

$$(S.A. \cos \theta) \times H \times P = \text{Heeling Moment,}$$

where H = height of C.E. above C.B. and P = wind pressure per sq. in.

These calculations work out accurately with a large vessel but when applied to models they are apt to be misleading, and really the best guide as to what actual sail area should be put over any given hull is experience of similar models. As a matter of fact, stability calculations are seldom indulged in by model designers or real yacht designers either, except in exceptional circumstances. It is, therefore, not considered advisable to go more deeply into the matter here. Should any reader wish to pursue his studies in this direction, he is referred to works on theoretical naval architecture. The object of the authors of these pages is not to complicate the subject unduly for the beginner, but to explain all necessary processes clearly.

BUILDING TO VARIOUS SCALES

If, however, one starts on these calculations, there are so many complications and such an infinity of results are obtained that the novice might well be excused if he came to the conclusion that naval architecture is one of the black arts. On the contrary, stripped of abstruse and theoretical calculations, it is a subject that can be understood by anyone who has learnt the first four rules of arithmetic.

Far be it, however, from the authors of this book to decry the work that has been performed by experimenters and mathematicians, as their labours have borne fruit in the vast improvements which have been made in hull and sail design during the past few years. And even if we have not the scientific facilities or mathematical knowledge requisite for carrying out similar research work, it should be our aim to keep abreast of developments as they occur and thus profit by the advance of knowledge. At the same time one must be wary of being led away and going to extremes before facts are properly established.

The resistance from wetted surface only represents a very small proportion of the total resistances to forward motion, but may play a very large part in light winds with a large model that has small sail area. In case any readers want to calculate the wetted surface of a model, the easiest method of doing this is as follows.

The girth of each half-section is measured up to the L.W.L. and the trapezoidal rule applied to find the total area. Obviously, however, there is a difficulty in doing this, as the distance between the section stations measured on the skin of the boat at the L.W.L. is greater than at the bottom where they are on the centreline. A kind of average is taken by applying a correction to the interval between stations. The interval is multiplied by the length of the bilge diagonal and divided by the length of the L.W.L.

If it is desired to build a scale sailing-model of a full-sized craft, careful calculation should be made beforehand to make sure that the model has an appropriate displacement and can carry her sail area. In making these comparisons it must be remembered that length,

breadth, depth, etc., are linear measurements, sail area square measurement, and displacement cubic measurement.

In similar fashion it is usually undesirable to build a model to a size other than the one she is designed for. Let us take our little 36-in. model with a L.W.L. of 28 in. and displacement 10.3 lb. Suppose the idea occurs to us of enlarging her bodily to a L.W.L. of 49 in. for use as a 10-rater. In such case every measurement would have to be enlarged in the proportions of 28 to 49 (= 4 to 7). The sail area would be multiplied by $(\frac{7}{4})^2 = 3.06$ and the displacement by $(\frac{7}{4})^3 = 5.35$. The sail area would, of course, have to be adjusted to suit the rule, but the displacement of $10.3 \times 5.35 = 55.1$ lb. could not be altered. As a 10-rater it would be totally out of place, and even as an A-class rather heavy for the waterline.

If it is desired to vary the displacement of a design, there are only two ways in which this can be done without destroying the balance of the design. If the station intervals are increased or decreased the displacement will be altered by the proportion the stations are placed farther apart or closer together. An alternative method is to enlarge or decrease the sections bodily. In the latter case the displacement will be increased or decreased by the square of the scale of the alteration, since the section areas are square measurements. If desired, a combination of the two methods might be employed, but in any case the builder can easily calculate his altered displacement beforehand.

One often hears model yachtsmen say that if so many square inches of sail will propel so many pounds weight, it gives a ratio of so many inches per lb. This is incorrect, as the proportions to be considered are $\sqrt{S} : \sqrt[3]{D}$ (taken in cu. inches).

An interesting corollary to this is in the A-class Rule, where contrary to general belief one finds that a boat of the bottom limit of displacement gets the greatest sail area on any given L.W.L. as shown by her sail-displacement ratio, and a boat of the top limit of displacement the least.

In order to assist the model designer to make

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useful comparisons, a table of Ratios for Comparison is appended. In this the L.W.L. is used for a basis of comparison.

Features for Comparison.	Ratio for Comparison.
L.W.L. (L) : Sail Area (S)	$L : \sqrt{S}$
L.W.L. (L) : Displacement (D)	$L : \sqrt[3]{D}$
Sail Area : Displacement	$\sqrt{S} : \sqrt[3]{D}$
L.W.L. : Max. Beam (B)	$L : B$
L.W.L. : Max. Draught (Dr.)	$L : Dr.$
L.W.L. : Wetted Surface (S)	$L^2 : S$
Displacement : Wetted Surface	$D^{\frac{2}{3}} : S$
Speed in Knots (V) : L.W.L. (in ft.)	$V : \sqrt{L}$

In all of the above except the last, inches, square inches and cu. inches can be used. Thus a boat with 48 in. L.W.L. and S.A. of 1,600 sq. in. would have a length-sail ratio of $48 : \sqrt{1,600} = 48 : 40$ or $6 : 5$.

In making comparisons of speeds between different boats, the speed-length ratio is the basis of comparison. Thus a boat with a speed of $2\frac{1}{2}$ knots and L.W.L. of 48 in. (= 4 ft.) has a speed-length ratio of $2\frac{1}{2} : \sqrt{4} = 2\frac{1}{2} : 2 = 5 : 4$ or 1.25 .

When one realises that many fast Atlantic liners have speed-length ratios of 0.9 or 1.0, the speed of our models is not so discreditable.

It may also be useful to remember that resistance varies as the displacement, as does also the heeling moment of the sails.

Much of the matter included in Chapter VII and the present chapter is rather technical and involves the use of logarithm tables, etc. This need not discourage the less mathematically minded, however, since simple practical alternative methods have been given for all essential calculations and operations. By the use of these, all mathematics except the simplest can be avoided. It is certainly necessary to be able to find square and cube roots, but Barlow's Tables of Square and Cube Roots will do all that is required in this direction and prove invaluable.

Having dealt with the subject of designing at some length, we are now ready to consider methods of building, thus turning our paper boats into actual yachts.

CHAPTER X

Preliminary Remarks on Building. Punts and V-Bottom Sharpies. Building a Sharpie.

BEFORE starting to describe the different methods that can be used for building models, a few general observations must be prefaced on points that apply whatever boat is being built.

Before starting to build or buying the material even, full-sized construction plans must be prepared. If you are working from full-sized plans you will avoid the labour of enlarging the design to full-size, but otherwise you will have to do this for yourself.

In enlarging a design, it cannot be too strongly emphasised that the greatest accuracy is essential. This is obvious when it is considered that if the enlargement is being made from a half-size plan, any error will be multiplied by two.

In enlarging a profile, the first thing to be drawn is the L.W.L. After this the sections are carefully spaced out and ruled in. These *must* be absolutely at right angles to the L.W.L. The other waterlines are now ruled in. The heights of the profile and sheer above and below L.W.L. are now transferred to the section lines and spotted in.

The correct method of doing this is to use a scale rule according to the relative enlargement. For instance, if the design has to be enlarged from half to full size, the measurement is read off the original design on a $\frac{1}{2}$ -in. scale and transferred to the enlargement on a 1-in. scale. The use of dividers or proportional compasses cannot be recommended, as the liability of error is far too great.

In making the enlargement, just as much care must be given to the straight lines as to the curves. They are just as liable to be wrong and will cause as much error and trouble.

In setting out from a table of offsets, the same methods are used. A "table of offsets" is a table giving the various measurements for the profile, sheer, sections and buttocks in a design. These are taken respectively from the L.W.L. or the centreline, as the case may be.

The intersections of the profile with the various waterlines and buttocks are found in this way, and spotted in. The outline of the boat is now shown by a number of dots. Using a lancewood spline or a pine batten, sweep in the profile and sheer through the spots. The batten is kept in place during this operation by weights. Care must be taken to get the lines exactly through the spots, and a well-sharpened pencil should be used to avoid thick lines. If the curves do not touch any of the spots, or on inspection look unfair, carefully check over the measurements.

A similar procedure is gone through in enlarging the rest of the design. Whilst doing this the intersections of the lines should be checked in the various plans, and everything faired up nicely as detailed in earlier chapters. When the full-sized plans are ready, the necessary construction plans can be made. As there are several different methods of building, and construction plans prepared for one method would not suit another, model designers only provide designs, leaving each builder to prepare construction plans to suit his own particular requirements. The only exception is in the case of model sharpies, where designers usually supply construction plans with particulars of scantlings.

In every form of building the first requisite is good glue. If joints are made with ordinary glue it is imperative to see that no water reaches them. It is, however, much better to use a waterproof glue. Casein glue, which incidentally is made from milk, is entirely waterproof, and will make the strongest possible joints. It is more in the nature of a cement than a glue, and useful for many purposes besides boat-building. One caution must be given about its use, however. It is prone to stain wood and, consequently, care should be taken in its use when working on wood that is subsequently to be varnished. However, in the event of wood becoming

stained in this manner, the mark can be eradicated by treatment with a weak solution of oxalic acid. Casein glue can be obtained from any good ironmonger, toolshop or stores. It is in the form of a fine white powder and should always be kept in an airtight tin.

Casein glue must be mixed about twenty minutes before it is required, and as it does not keep from day to day only sufficient for the day's work should be made up. Add to a little water sufficient glue to form a thick cream and stir thoroughly until it forms a smooth paste. Stand aside, and in about twenty minutes a change in the nature of the glue will be observed. Coat both surfaces that are to be joined and press them together. You can take your time in lining up and getting the two parts in their correct respective positions as this glue (unlike hot glue) does not dry quickly. The joint must be kept under pressure until dry, which takes at least twelve hours, though twenty-four hours should be allowed if possible. Joints properly made with this glue are actually stronger than the solid wood itself.

It will be unnecessary for us to refer to casein glue again, or repeat the instructions for its use, but the reader will understand that whenever glue is referred to casein glue should be used.

All pins or nails used should be either brass or copper, and only brass screws should be used. When these are used for chromium-plated deck fittings they should be plated to match. Chromium plating is rather more expensive than ordinary plating for fittings, but gives a better appearance and wears better. If the reader will remember that all fastenings should be non-rusting it will save our mentioning it every time a nail or screw is referred to.

After these preliminary remarks we can now turn to the various kinds of yachts and methods of building them.

* * * *

The simplest form of sailing boat is the sailing punt. In a full-sized sailing punt a centre-board is fitted and the crew act as

ballast; but in a model a plate keel with a lead bulb is used. The punt is a flat-bottomed craft, the floor being usually straight across from bilge to bilge, but rockered in a fore-and-aft direction.

Apart from having a transom forward as well as aft, the construction of a model punt is almost identical with that of an ordinary V-bottomed sharpie, except that the bottom can be put on in one piece.

A sharpie is slightly more difficult to build than a punt, but as it is an infinitely better boat the extra trouble is well worth while. A sharpie is a boat with a pointed bow and a chime. There is a certain amount of prejudice against the type in Britain, but non-success is often attributable to inferior design rather than to any fault in the type.

In the U.S.A. there is a most successful one-design class of sharpie yachts, known as the "Star" class. It was designed by the late Mr. William Gardiner, the celebrated American designer, and inaugurated about thirty years ago. The boats of this class number some hundreds, and it is the most successful one-design class in the world. This in itself is sufficient proof that, given a good design, the sharpie is as capable as any ordinary yacht, besides being cheap and easy to construct.

In class rating rules for models, with the exception of the 10-rater, either some restriction (such as the restriction on hollow garboards in the M-class) or the method of measurement, preclude the possibility of designing a successful sharpie to the rule. The model builder is, therefore, advised not to build a punt or sharpie except as a 10-rater or a "free-lance" sailing model.

Sharpies are of two kinds—V-bottomed and round-bottomed. The round-bottomed type, though more trouble to build are better sailing boats as a rule. From the model builder's point of view, the difference is that, provided the angle of the V-bottom keeps more or less constant throughout the length of the boat, the bottom can be made in two parts with the joint on the centreline. In all other respects the construction of the two types is exactly alike. The methods of construction given

apply to a round-bottomed sharpie, but, bearing the above notes in mind, the reader will be able to modify them suitably for a V-bottomed sharpie or even a sailing punt.

We can now consider the question of construction plans for building a model sharpie. Now the boat is to be built upside down, the sides and bottom being bent to shape round templates known as "moulds." During building operations the moulds are erected on a "building board" to form a jig (or former) round which the boat is built.

On the profile plan draw a line parallel to the L.W.L. from a point about $\frac{1}{2}$ in. above the stemhead. This line represents the upper face of the building board, and to facilitate erection the stem, transom and moulds are extended to the "datum" line which has just been drawn. This datum line is repeated on the body plan.

The method of erecting the jig will be seen in Fig. 47. It will be noticed that the moulds are in two parts—the lower parts, which are the mould proper, and upper parts marked B. The latter are permanent floors built into the boat, while the moulds are temporary templates which are removed when the hull is finished. The square pieces marked A are cross-pieces of wood 1 in. square screwed across the building board to hold the templates rigidly in position.

There is one important point to observe in this diagram, and that is the position in which the moulds are erected in relation to the section station lines. The upright lines across the building board represent the station positions. It will be seen that *the moulds in the forward part of the boat have their after faces on the station lines*, and in order that this may be so *the cross-pieces are placed the thickness of the mould forward of the station lines. The moulds in the after-part of the boat have their forward faces on the station lines*, and therefore *the cross-pieces are dead on station*.

Before proceeding with our construction plan we have to decide on scantlings. For planking a small sharpie under 36 in. overall $\frac{1}{8}$ in. wood can be used, but for anything larger up to a 10-rater $\frac{1}{4}$ in. must be used.

Other scantlings suitable for a 10-rater model are: Inner Keel (or Kelson), 1" $\times$ $\frac{1}{4}$ "; Chime

Stringer, $\frac{5}{8}$ " $\times$ $\frac{5}{8}$ "; Inwales, $\frac{3}{4}$ " $\times$ $\frac{3}{8}$ "; Stem, $\frac{3}{4}$ " (fore-and-aft at stemhead) $\times$ $\frac{3}{4}$ "; Floors, $\frac{1}{4}$ " thick; Transom, $\frac{1}{2}$ " thick. These scantlings can be proportionately lightened for a smaller boat.

A mould plan has now to be prepared from the body plan, taking off the thickness of the skin planking. Do not measure this in along the waterlines but at right angles to the skin.

For the benefit of those who are unfamiliar with the terms, the chime (sometimes called "chine") is the angle formed by the sides and bottom in this type of boat. The chime stringer is a longitudinal member of the boat's framing running along inside the skin at the chime. The kelson (or keelson), otherwise known as the "hog" (or hogpiece), is an inner keel. The "floors" are transverse girders extending across the kelson from chime to chime.

For a boat 36 in. long a plain building-board, 4" wide by 1" thick, will suffice, but for anything much larger a rather stiffer construction is required, and a T-section building board can be made up. The top can be 4" $\times$ 1", and the upright of 3" $\times$ 1" wood. Only the top member of the building board is shown in Fig. 47. The board should be a few inches longer than the boat to give room for fastening the stem, etc., and the two parts must be firmly screwed together.

The moulds are cut from $\frac{1}{4}$ in. pine and erected on the building board. They are erected by being screwed to cross-pieces of wood 1 in. square, which are fixed across the top of the building board. Put the screws holding the cross-pieces through from the underside of the board or it will be impossible to remove them when the boat is built. Also be careful to get the moulds with their centreline dead on the centreline, which should be put down the building board. In setting up be careful to place the moulds correctly as regards their station lines as already explained.

During working the upright member of the building board can be held in the vyce. The floors are made from good quality yellow pine, $\frac{1}{4}$ in. thick. Their ends butt against the chime stringers, and at the end they are the same

depth as the stringers. The centres of the floors have to be notched for the kelson, and it should be noted that though the notches are the full depth of the kelson at the centre, they are less at the sides owing to the rise in the floors. It would be as well to prepare the kelson before finishing off the notches. The kelson, like the floors, can be yellow pine, and this wood can be used for chime stringers and inwales.

Put the floors in their correct positions on top of the moulds, holding temporarily in position with a couple of fine brads. These must not be driven home, as they will have to be withdrawn when we reach this part of the bottom planking.

The material and method of making the transom will depend largely on how the boat is being finished. If the boat is being painted, white pine can be used for the planking and transom, but if she is being varnished cedar or African mahogany looks better, but even in a varnished pine boat a mahogany transom makes a nice finish.

If a mahogany transom is being used, the best result is obtained by using an inner transom which can be $\frac{3}{8}$ -in. pine. When the boat is planked up, an outer transom of $\frac{1}{8}$ -in. mahogany is glued on, giving the effect of rebated plank-ends. If this is being done the inner transom must be set up $\frac{1}{8}$ in. forward of the extreme length of the boat.

The transom, like the moulds, must be made the full length to the building board, and if it is raked the cross-piece which holds it to the building board must be bevelled to the correct angle. The screws holding the transom to the cross-piece will come in the piece of spare wood at the top of the transom.

The stem should be of hardwood. If the boat is varnished pine, it can be oak, but otherwise mahogany should be used. It is made long enough to come to the building board and a tongue left on the fore-side to screw it to the building board. Having cut out the stem, draw a centreline all the way round it. Use a marking gauge if you have one. Down the fore-side draw two lines parallel to the centreline $\frac{1}{8}$ in. on either side of it. This gives $\frac{1}{4}$ in. for the cutwater (foreside of the stem).

On the plan view of a sharpie the deckline and chime line are shown. If the stem is put in on this plan it will give the builder the top and bottom positions for the rabbet line.

It should be explained that the ends of the side planking are housed in a rebate in the stem, and the "rabbet" line marks the forward end of this. The planking gradually runs out of the stem and the "bearding" line is where it comes clear. The groove in the stem is, therefore, $\frac{1}{8}$ in. (or whatever the thickness of the planking is) deep at the rabbet line and runs to the surface at the bearding line. The rabbet can be chiselled out accordingly. The stem itself is full width at the rebate and tapers forward to the cutwater. It can be finished off this way. The bottom of the stem has to be cut away to accommodate the bottom planking to a depth of $\frac{1}{8}$ in. The forward end of this recess comes half-way between the rabbet and bearding lines. A further slot has to be cut at this point to accommodate the forward end of the kelson, and the forward end of this should come about $\frac{1}{8}$ in. aft of the bearding line. It is important to arrange these slots so that the ends of inner members of the structure are covered. The stem is now set up on the building board.

The kelson can be fitted. It lies forward in this slot in the bottom of the stem, amidships in the notches in the floors, and aft in a notch in the transom. It is glued and screwed to each of these members.

After the kelson is fixed the chime stringers must be fitted. The forward ends are bevelled off to butt against the stem and the after ends house in slots in the transom. The middle parts lay along the top of the moulds butting against the floors. It will be noticed that the ends of the floors require to be bevelled off to the curve of the sides to permit the stringers to take properly on them. The bottom of the stringers will have to be bevelled off to the curve of the bottom later. Therefore the outer bottom corners should stand proud (*i.e.*, be above their surroundings) when first offered to the boat. The ends of the stringers are glued and screwed in place, and they are glued and pinned with brass pins to the ends of the

floors. In gluing care must be taken not to let any glue run on to the moulds or difficulty may be experienced when the boat has to be taken off them. In passing, it may be mentioned that, as a rule, it is bad practice to put fastenings into the end grain of wood, but in fastening the stringers to the floors it is unavoidable.

Before the framework is ready for planking, the moulds have to be faired up. Take a thin flexible batten and offer to the sides. It will be found that on the forward moulds it only touches the forward edge. Now the after faces of these moulds give the correct shape of the hull on their exact stations. Take a rasp and bevel off until the batten takes right across the mould.

In the after part of the boat the batten touches the after edge of the moulds, and these also must be bevelled off.

The batten is then tried on the bottom and the floors and transom faired up in a similar way. If the outer edges of the kelson are still standing proud, these also must be faired down flush with the floors. The chime stringers should also be checked and any necessary fairing down attended to.

We are now ready to start the planking. If we are building a V-bottom boat the whole of one side of the bottom can be in one piece, but if she has a round bottom four or five planks a side will be needed. We will assume the latter, the procedure for a V-bottomed boat being exactly the same except that a wider piece of wood is used.

We will start with the two centre planks of the bottom, which have their joint dead down the centreline of the hull. Take a strip of planking wood about 2 in. wide and offer to the boat. It will be found that while the ends can be got into position on the centreline there is a considerable gap in the middle of the boat. Tack temporarily in position with fine brads.

We now have to "spile" the plank to get its correct shape. Take a pair of dividers and set to the width of the gap between the centreline and the plank at its widest place. Keeping one leg of the dividers on the centreline, prick this distance on to the plank at the position of

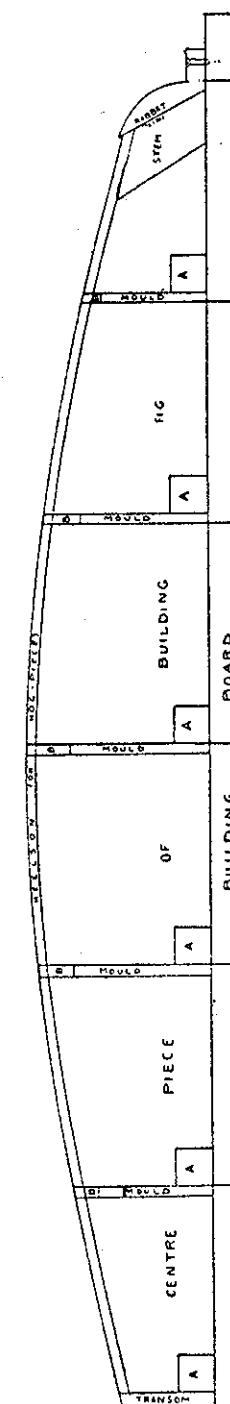


FIG. 47.—METHOD OF SETTING UP JIG FOR BUILDING A SHARPIE.
A = Cross-pieces of Building Jig. B = Floors of Boat.

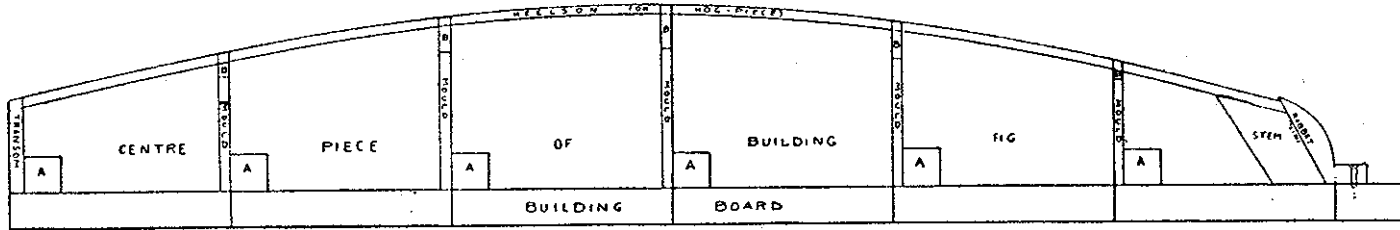


FIG. 47.—METHOD OF SETTING UP JIG FOR BUILDING A SHARPIE.

A = Cross-pieces of Building Jig. B = Floors of Boat.

each floor, being careful to keep the dividers square to the centreline. If the floors are rather wide apart, take other positions half-way between as well. Remove the plank from the boat, and using a batten, run a line through the spots just found. If the wood is cut to this line it should give you the shape of the inner edge of the plank. After cutting, offer to the boat to check. If all is well, remove and at the position of the centre floor mark the width of the plank. On a normal 10-rater sharpie this can

The planks are glued edge to edge and to floors, stem, transom and kelson. For fastening to the chime stringers use small copper nails.

The next plank is similarly shaped to fit against the centre one and duplicated, the pair of planks being put on as before. The other planks are similarly fitted. There should be no gaps anywhere between planks, but if a bit of bad fitting has occurred it can be caulked with plastic wood. This material can be had in

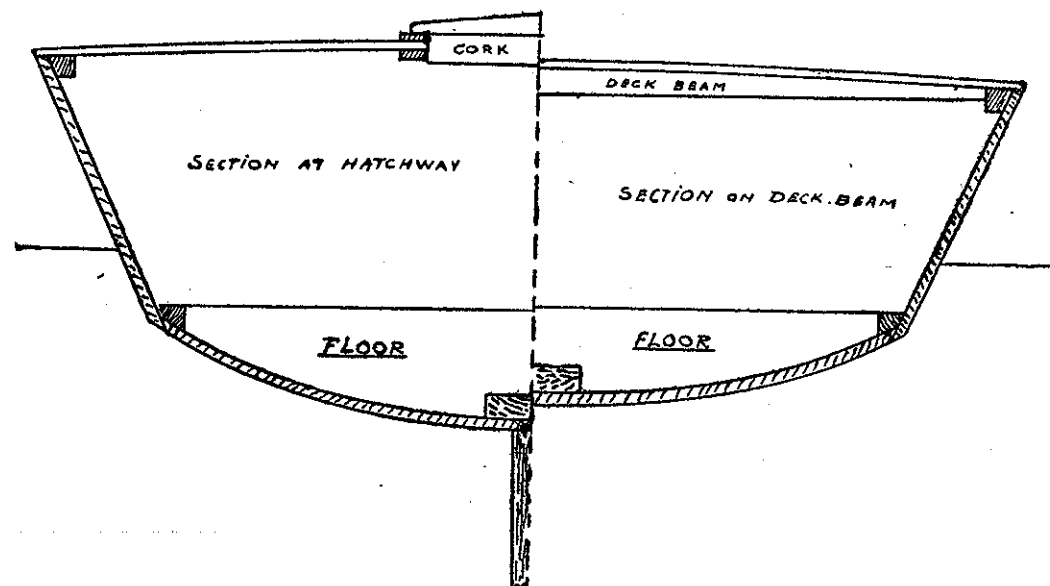


FIG. 48.—MID-SECTIONS OF A SHARPIE SHOWING CONSTRUCTIONAL DETAILS.

be 1 in. wide. Mark the outer edge of the plank with a straight-edge parallel to the original edge of the strip of wood.

Make an exact duplicate of this plank for the other side. Try the two and see they fit along the centreline of the boat. It should have been mentioned that the sides overlap the bottom, and therefore the outer edges of the bottom planks lie flush with the outside of the chime stringers. Leave these edges a little full during planking and trim up before the sides go on.

When the planks are fitted they are glued and fastened into position. Fasten with small screws to transom, stem, kelson and floors.

natural and mahogany colours, and the latter should be used if you are constructing a varnished mahogany hull. Plastic wood shrinks considerably during drying, so any stopping should be left proud and not rubbed down for at least forty-eight hours.

Before the sides can be fitted, the plank edges of the bottom must be trimmed sharp to the chime stringers, using a piece of glass-paper wrapped round a piece of wood. Take care not to round the edges off or the joint with the sides will be unsatisfactory.

To mark out the side, the first thing is to fit the fore end to the rabbet down the stem in which it houses. Take a slip of cardboard 2 in.

wide, having its two sides absolutely parallel. Offer the plank to the boat and at the same time place the cardboard with one side in the rebate. Draw the wood back until it can be marked out most economically. Then, using the edge of the card as a guide, mark the wood to get the angle of the stem rebate and cut accordingly. Again offer to the boat and put the forward edge into the stem rebate. Tack lightly in position. By running a pencil along the chime you get the shape of the bottom of the plank. At the same time mark the position of the floor stations. Remove the plank and square a line up it at the position of each floor station. Measure the heights of the side at each station from the body plan and mark on the plank.

If the deck is going to be let in flush with the top of the sides the full height is taken, but if the deck is going to be laid on top of the sides the thickness of the deck must be subtracted from the heights found. It should be noted that the distance round the sides is greater than the spacing of the floors owing to the curvature, so the positions for the stations must be taken in this way.

Cut out the side, trimming the top edge sharp to the sheer line but leaving the bottom a shade full. Also leave a slight overlap at the transom. Make a duplicate plank for the other side of the boat.

The sides are now glued and fastened into position. The ends are screwed to stem and transom, and the bottoms glued and nailed along the chimes. When the glue is dry, trim the sides flush with the bottom, using a piece of glasspaper wrapped round a block of wood.

The boat can now be removed from the moulds. In order to prevent the sides spreading until the deck beams are fitted a temporary tie should be used. Take a piece of wood

about 3 in. wider than the greatest beam and nail two blocks of wood at the ends at such a distance apart that they will just take the top edges of the sides, and place across the boat's gunwales.

The inwales have now to be prepared and fitted. The fore ends are bevelled off and butt against the stem just as the chime stringers did. The after ends butt against the transom. It is, however, possible that at the transom it will be necessary to taper the inwales off on the underside to lie on top of the chime stringers.

The inwales are glued in place and fastened. The ends have screws going through planking and inwales into the stem. Along the gunwales they are fastened with small copper nails. It should be noted that if the deck is being dropped in flush the inwales are put the thickness of the deck below the top of the side planking. If the deck is not being dropped in they are set flush with the top of the side planking. It is recommended in a boat of this sort that the deck be dropped in, but it is not necessary.

If the boat has a plate keel this will have to be fitted to the hull and fixed with brass screws from the inside. This is only likely in smaller sizes of models, and if the keel is a shaped one, it will have to be built up bread-and-butter as described in the next chapter, and bolted on with cycle spokes.

Whichever form of keel is used, it is most essential to get the keel correctly aligned and absolutely vertical. The joint between the centre planks gives the correct fore-and-aft line. In order to get the keel dead vertical, chock the boat up evenly and test with a spirit level. A plumb-bob can then be rigged up over the centreline and the keel checked up by this means.

Deck-beams are put in and the boat finished off as described in later chapters of this book.

CHAPTER XI

How to Lay Off a Bread-and-Butter Hull. Method of Building. Removable Keels.

THE name "bread-and-butter" is given to the system of building hulls by laminations. By this method, layers of wood of a convenient thickness are superimposed until there is sufficient depth to make the body of the yacht. The layers are glued together, hence the name "bread-and-butter," the wood being the bread and the glue the butter presumably.

A hull can either be planked up on ribs like a real yacht, or she can be carved out. The most primitive method of carving a hull is to get a solid block of wood and carve her away outside until the desired shape is attained, and then hollow her out. There are several objections to this method. For one thing, it would not be easy to get a block of wood of sufficient size to make a model even as large as a rater, and an A-class model would be worse still. Again, such a block of wood would be very heavy and awkward to handle, and, finally, it would be a very difficult matter indeed to build a boat to conform with any lines by this method.

Bread-and-butter construction has many advantages. It is the easiest method for an amateur to undertake, and it also takes less time than planking a boat, whilst the resultant hull can be made lighter than one that is planked. The bread-and-butter hull is also quite as strong, provided the glue joints are well made with waterproof glue and properly protected with paint. It is also easier to repair in case of accident, and (though this does not apply to well-tried designs, such as are published in this book), if it is desired to make an alteration to the keel or fin, this can be done without disturbing the topsides in the least. The main objections to the method are that it is rather more expensive, as it uses more wood, and is somewhat less "shippy," as real yachts are not built by this method. On the score of accuracy there is nothing to choose between this method of construction and

planking, and everything depends on the accuracy with which the builder works to the design.

The preliminary steps in building a boat are most important, as any lack of care will have a detrimental effect which cannot be remedied later on, and whatever method is employed, the greatest care is essential in laying the boat off correctly.

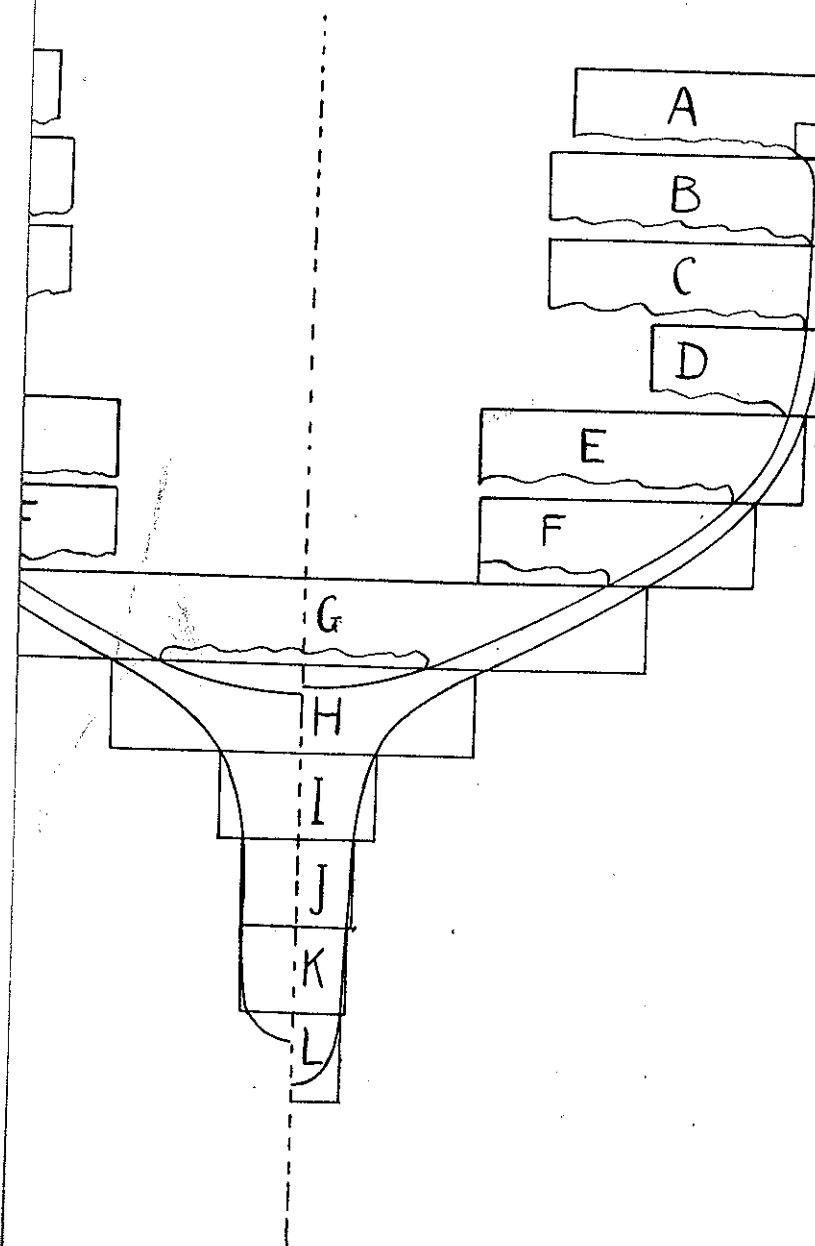
The method of preparing a full-sized design to work from has already been described, but it must also be calculated whether the waterlines on the design are conveniently spaced. The most usual distances between waterlines for bread-and-butter building are $\frac{3}{4}$ in., $\frac{1}{2}$ in. or 1 in. This gives layers (or "lifts," as our American cousins prefer to style them), $\frac{3}{4}$ in., $\frac{1}{2}$ in. or 1 in. thick as the case may be.

As explained in an earlier chapter, the waterlines represent horizontal planes parallel to the waterline plane. If, therefore, layers are cut out to the shapes of the waterlines and glued together, a solid block of wood will result, that only requires the "steps" cutting off to give us the shape of the boat in accordance with the design.

As already stated, the best wood to use for a bread-and-butter hull is first-quality pine. It can usually be obtained in wide boards, but if these are not available, the requisite width can be made up by glueing a piece to the side of the board.

In order to save wood and reduce the labour of hollowing out, the wood is cut from the inside of the larger layers and used for the lower layers, which are smaller. It will, therefore, be necessary to study the full-sized design carefully to work this out. As this will effect the quantity of wood needed, this is best calculated before the wood is bought.

It is not, however, merely a question of which waterline is smaller. In addition to this, it must be so arranged that enough wood is left when the inside of the larger layer is



VIEW OF BREAD-AND-BUTTER HULL, SHOWING METHOD OF CONSTRUCTION.

[To face p. 96.]

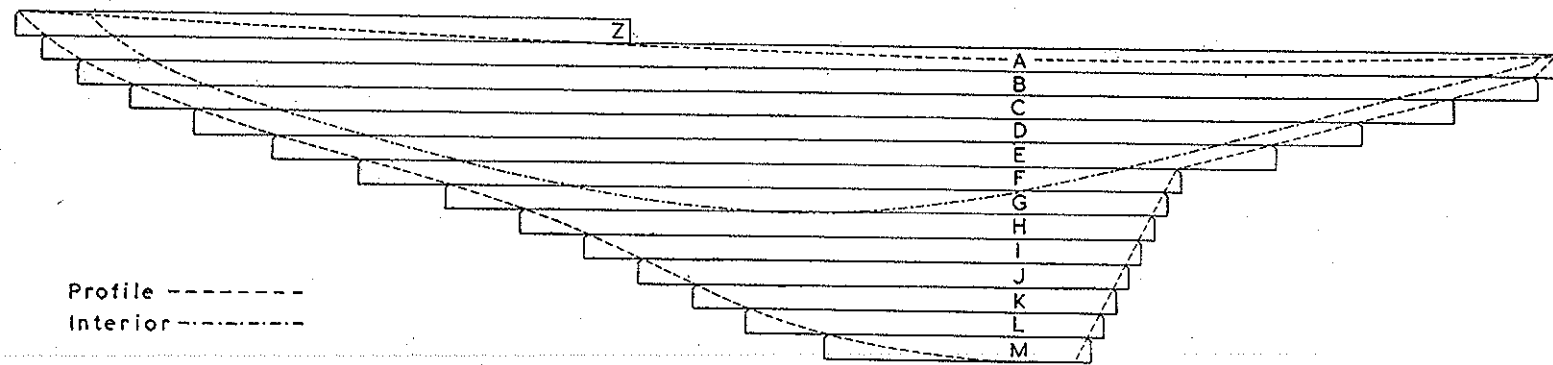


FIG. 49.—METHOD OF BUILDING A BREAD-AND-BUTTER HULL.

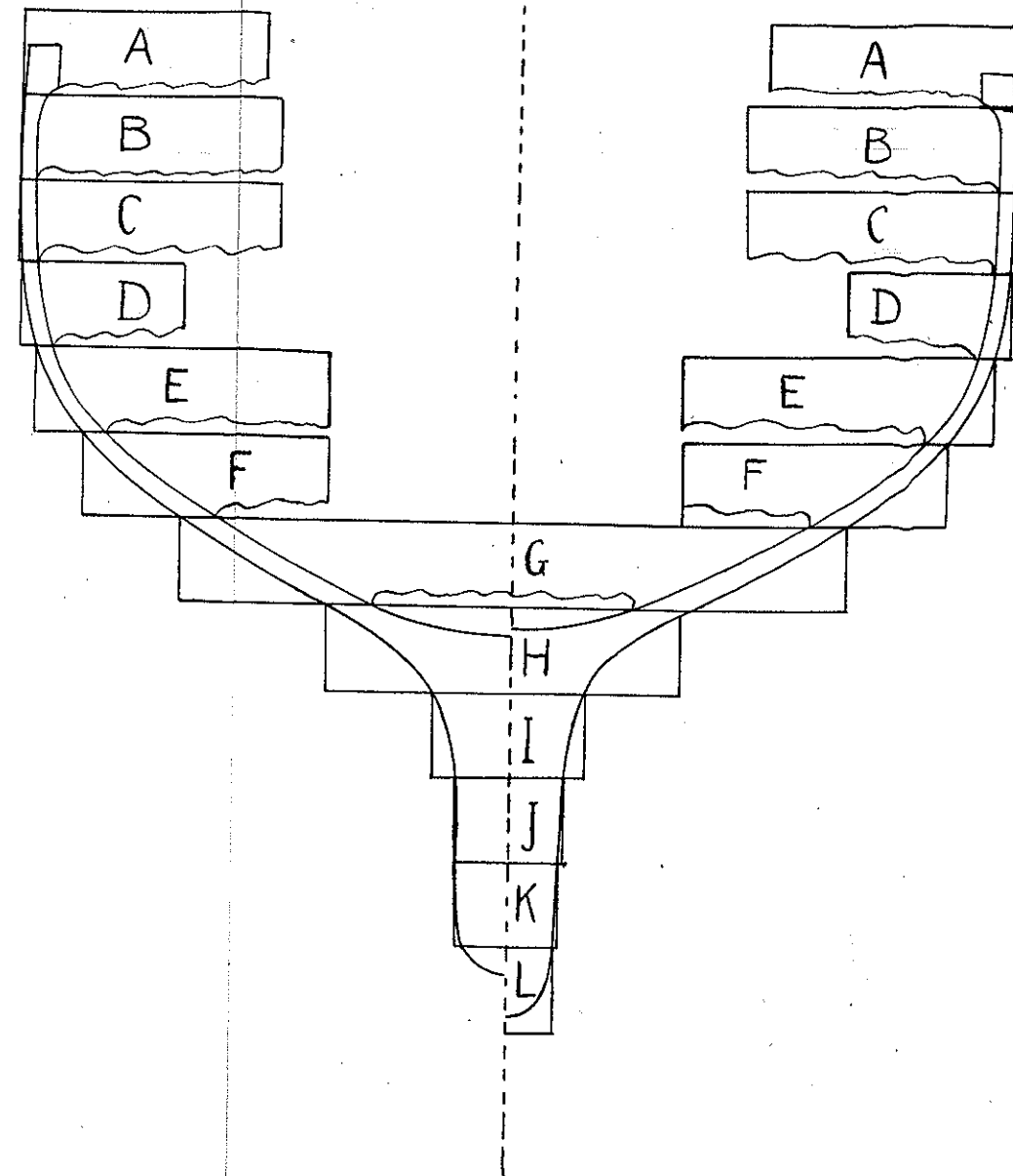


FIG. 50.—SECTIONAL VIEW OF BREAD-AND-BUTTER HULL, SHOWING METHOD OF CONSTRUCTION.

MARKING OUT THE LAYERS

cut out. At the sides of the boat, where the hull is more or less vertical, about an inch will suffice. It is not wise to cut much finer than this, as otherwise the layers may twist and go out of shape before they are glued up. The ends are a little more difficult to calculate. Obviously, each layer will be cut to the size of its bigger face, but the amount to be cut out inside will have to be regulated by the smaller face. Actually, when finished, the hull will be $\frac{1}{8}$ in. thick, or a little less. The width which has to be left at the ends of the layers can easily be seen by measuring up from the profile. For instance, if the profile rises at an angle of one in four from the horizontal, and the desired thickness is $\frac{1}{8}$ in., the amount that would have to be left would be exactly $\frac{1}{4}$ in. This is, of course, the width of the joint at this point. In craft of the scow type, such as a ro-rater, where the angle of incidence of the profile is lower, the amount to be left would be correspondingly more.

The amount to leave at the ends can best be ascertained by striking a line on the profile plan representing the inside of the hull, leaving the necessary thickness down the stem and along the bottom in the way of the mast step. The amount to leave in these places depends entirely on the size and weight of the model. For an A-class 3 in. would not be too much down the stem and $\frac{3}{4}$ in. at the mast step.

The builder should now be able to work out how much wood he needs. The thickness of wood to buy will depend on the spacing of the waterlines, and it should be remembered that this is the finished thickness of the wood. Thus to get 1 in. finished it is necessary to buy wood $1\frac{1}{4}$ in. thick. It is very important to have the wood finished to the exact thickness required—as the design will be distorted if this is altered.

In order to make strong glued joints, good contact between the surfaces is essential. Accordingly, the wood must be planed dead flat and smooth. Unless the builder has a good jack-plane, and can use it well, it is advisable to have the wood planed to thickness at the saw mills. This costs very little extra and is worth while to save time and labour. When

ordering, specify for the wood to be planed to the exact thickness required and stress the need of accuracy. When taking delivery, check the thickness carefully to see your instructions have been carried out. In checking, it is a good plan to measure over several thicknesses, since any error will then be multiplied and show up readily.

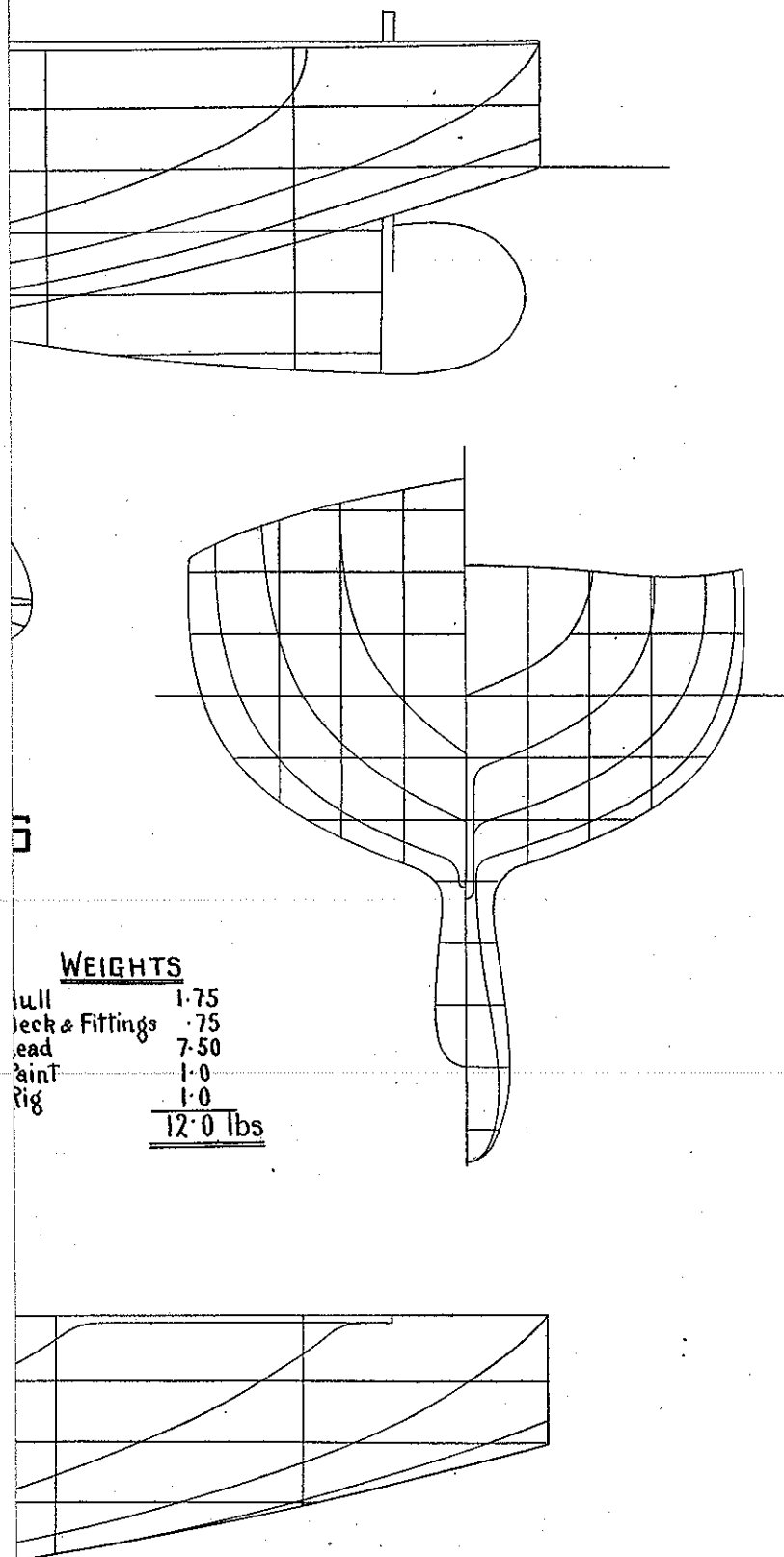
The first thing to do is to mark out the layers. Square up the edges of the board and accurately strike a centre line on both sides. The buttock lines and section lines must then be put in, and the latter squared off right round the plank to make sure they coincide on both sides. Starting with the largest complete layer, which is marked A in Figs. 49 and 50, proceed to mark in the half-breadths on each side of the centreline. Also spot in the intersections of the waterlines and buttocks. Only the larger of the two waterlines which represent the faces of the layer need be marked in. If there is a tumble-home a slightly different procedure will be needed.

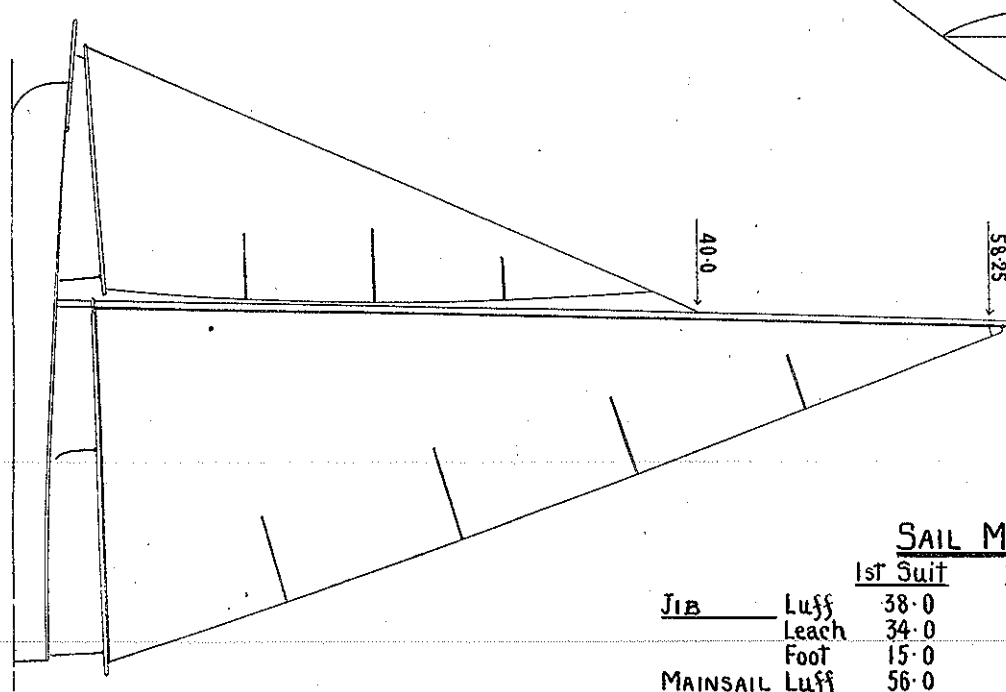
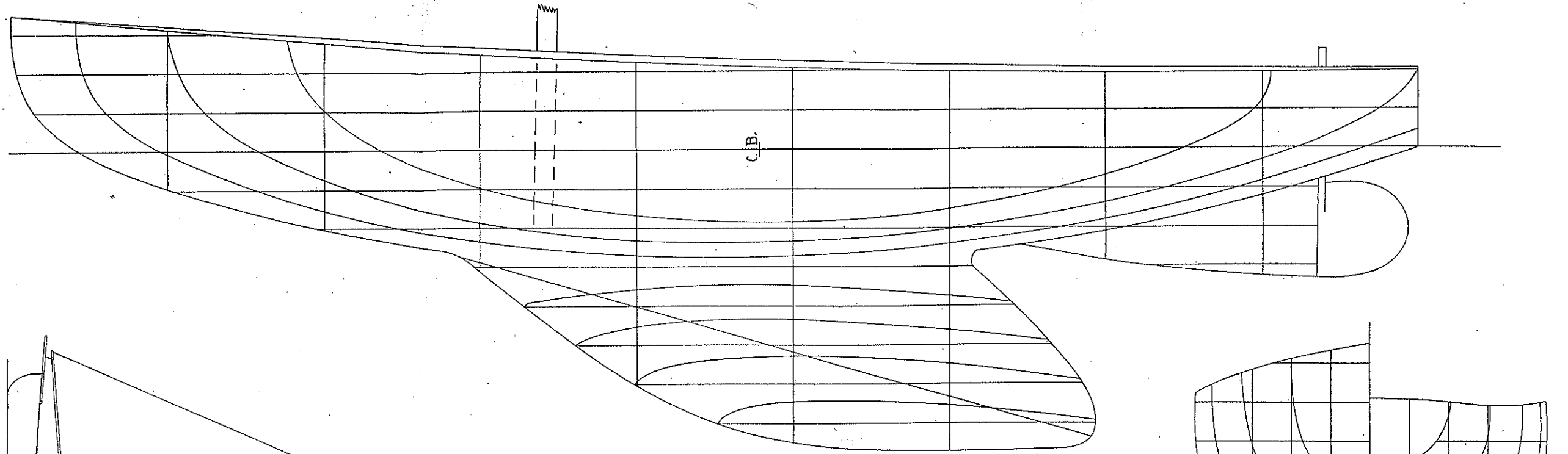
The term "tumble-home" is used when the width of the hull at deck level is less than at one of the lower waterlines. If the hull that is under construction has any tumble-home, the extra width for this must be allowed when the wood is cut. Any part that is wider on the lower waterline than the upper one must be drawn in on the top face of the layer as well as the waterline that belongs there by rights.

Having put in all the spots for the half-breadths and buttock intersections, a line must be drawn in with a fine hard pencil. This is done with a spline, which can be held in position with tacks or weights during the operation. Be careful that this intersects all the spots exactly, and if any part does not make a fair curve, check the measurements carefully.

The inside of the layer has next to be marked for cutting out. The layer which it is decided shall be taken from the centre of the largest one must then be marked in the same manner. In each case the largest layer that will come out comfortably should be selected. This inner layer will have to be marked out in a similar manner.

M.S.C.





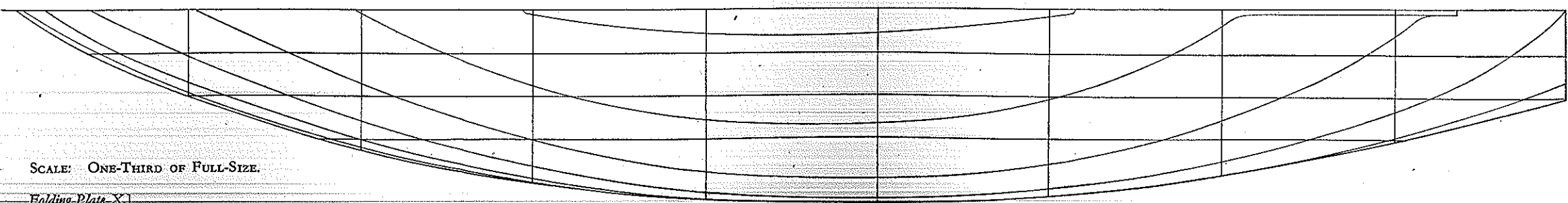
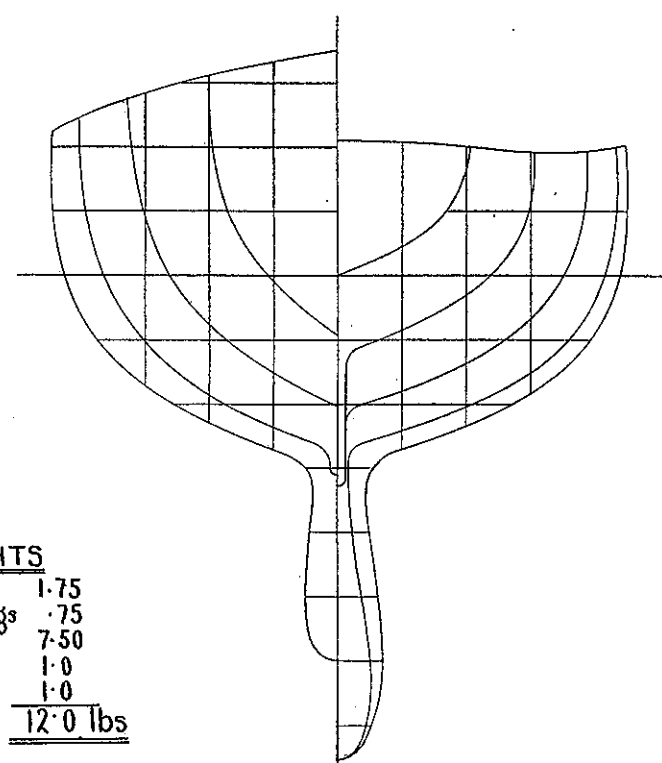
36-inch RESTRICTED CLASS MODEL YACHT

SAIL MEASUREMENTS

		1st Suit	2nd Suit	3rd Suit
<u>JIB</u>	Luff	38.0	34.2	30.4
	Leach	34.0	30.6	27.2
	Foot	15.0	13.5	12.0
<u>MAINSAIL</u>	Luff	56.0	50.4	44.8
	Leach	58.5	52.65	46.8
	Foot	22.0	19.8	17.6

WEIGHTS

Hull	1.75
Deck & Fittings	.75
Lead	7.50
Paint	1.0
Rig	1.0
	<u>12.0 lbs</u>



SCALE: ONE-THIRD OF FULL-SIZE.

Folding-Plane-X.]

[To face page 97.

After the largest layer has been marked out, together with those that come out of its middle, the next layer down will have to be attended to. The inside of this layer is again used for smaller layers, and the remainder of the layers are likewise marked out.

The more or less V-shaped piece required for the half layer Z (see Fig. 49), that forms the sheer forward, can be arranged to come out of the board that forms about the third or fourth layer down by taking it from the end piece of the board forward of the actual layer.

When all the layers are marked out, they

sharp chisel and a finely-set small plane should be used for the purpose.

When this has been done, the smallest layer can be used to mark the waterline of the lower face of the layer above it. This procedure is continued until each layer is marked on both faces. This will give the outside shape of all the joints.

It is now necessary to draw on the bottom face of each layer a line to represent the inside of the glued joints. Earlier in the chapter it was explained how to set off the thickness requisite at the ends. This is done on the

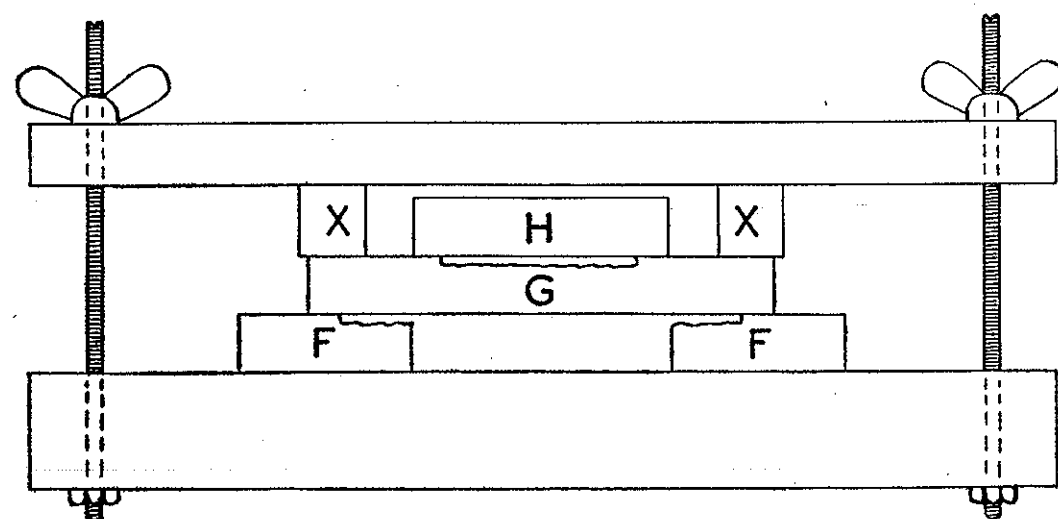


FIG. 51.—THE GLUEING-UP CRAMP IN USE. N.B.—Bolts are not shown full-length. X = Packing pieces.

can be sawn. If this is being done at home, the best tool to use is a bow-saw. Failing this, a compass (or keyhole) saw can be used, but the bow-saw will be found far easier work.

If there is a steam fretsawing works near and time is an object, it should not be an expensive matter to get the layers cut. Ask the sawyer to make sure that the saw is cutting absolutely perpendicular to the table, and instruct him to cut about $\frac{1}{8}$ in. outside the lines.

After the layers have been cut, they must be prepared for glueing up. The first thing to do is to trim the larger face of each layer down absolutely sharp to the pencilled waterline. A

centreline at the ends, and also on the midship section for the sides. A very simple dodge for marking the inside of the joint after these points have been found is to use the next smallest layer. Place this in position on the underside of the layer to be marked, and draw it back diagonally until the spot at the end and the spot at the midship section are uncovered, and run a pencil round the edge through the spots. This is repeated for the other three-quarters of the layer.

The next step is to cut a small groove round each layer on the line which shows the inside of the joint. This is best done with a small sharp V-chisel. Having cut the groove, the

surface of the wood inside should be carved down sufficiently to avoid contact. By this means, contact will only be made on the parts which will be the finished joint. This gives full pressure on the right spot when glueing up, and also permits the air to get to the joint, which facilitates the glue setting. Another advantage of the groove is that it will act as a guide as to the thickness remaining when carving down the inside of the hull. This is clearly shown in Fig. 50.

The section lines and centreline should now be squared round the edges of the layers where they have been cut away, as these lines are used in setting the layers in their correct relative positions. It is most essential that this lining-up is correctly done as otherwise the boat will be all out of shape.

The layers are now ready to be glued together, and as mentioned previously, casein glue should be used. When glueing up, the layers must be cramped together. Ordinary G cramps are not much use for this purpose, but special cramps can be made up for a few pence. These are shown in Fig. 51. The bottom bar of the cramp is a piece of hardwood 2 in. $\times$ 1 in., and the top a piece 1 in. square. The bars are 4 in. wider than the greatest beam of the boat, and have the holes for the studding 1 in. from the ends. Studding is iron or brass rod threaded all along its length, and is a standard product obtainable from any good ironmonger. For these cramps $\frac{1}{2}$ in. studding is used and the lengths should give the cramp an opening sufficient to take the full depth of the canoe body of the boat, the keel being made up separately as explained later. For a 30-in. boat four of these cramps would suffice, but ten would be necessary for an A-class.

The first layers to be glued up are the bottom two of the canoe body of the hull. In Fig. 50 this would be layers H and G. The process of glueing was described in the last chapter, so there is no need to repeat it here, except to remind the reader that in lining-up, the centreline and section lines must register *exactly*, and that the builder can take his time over the lining-up as casein glue does not set quickly. The layers are cramped up with the

cramps just described. Put one at each end of the layers first, and the others in between. Be careful to screw down evenly, not one side first. Before screwing down firmly, verify the position of the layers again in case they have shifted while the cramps were being adjusted. Finally, screw down firmly and give a final look to the alignment. Then set aside to dry for twelve and preferably twenty-four hours.

The next layer to be added will be F. Now the pressure is required on the joint between layers G and F. If the cramps are put across the bottom of layer H, pressure will be put on the wrong spot, and this will also tend to distort layer G. Packing pieces are cut from some of the waste wood left over from the layers, and placed between the cramps and layer G to bring the pressure on to the right spot. This is shown in Fig. 51.

The remaining layers of the canoe body are added in similar fashion. On no account hurry the glueing process, but see every layer is aligned correctly and allow sufficient time for each glue joint to dry thoroughly.

The fin layers are built up in a similar manner, but these have to be drilled for the keel-bolts before glueing up. The positions for the keel-bolts should be accurately marked off on both faces of each layer. The best method of drilling these is to drill about half-way through from the top and then drill the other half of the way from the under face. The best things to use for keel-bolts are motorcycle spokes, but cycle spokes will be sufficiently strong for small boats. If the builder does not possess a die to thread these, the cycle dealer should be asked to put $1\frac{1}{2}$ in. of thread on them. Two or three keel-bolts will be sufficient for a small boat and four for an A-class. In order to minimise the chance of the keel wringing, it is better to have the keel-bolts well spaced out.

When the fin is glued up, it must be shaped before the final joint is made between it and the hull. It is not wise to finish quite up to this joint, as the contour is always affected by the next layer. The reason for finishing the fin before fixing to the hull is to get the pattern for the lead keel.

MODEL SAILING CRAFT

In order to hold the fin securely during the operation of shaping, a spare piece of wood can be fixed to it, the whole being held together by the keel bolts. The spare piece of wood can be held in the vice in a convenient position, leaving both hands free for the work. In carving down, chisel, gouge and small plane are all used until about $\frac{1}{8}$ in. from the waterlines. Coarse glass-paper is then used, finishing off with fine. During the rubbing down the glass-paper should be wrapped round a piece of thin wood.

When the fin is shaped, the lead-line must be marked in from the design. Now if the pattern was cut off exactly on this line, the width of the saw cut would be lost and the lead would not fit properly. In order to obviate this, a line should be marked $\frac{1}{8}$ in. below the lead line. The pattern is sawn off, running the saw cut between the two lines. The pattern and the residue of the fin are trimmed dead down to the marked lines.

Take a piece of wood a full $\frac{1}{8}$ in. thick and glue a strip along the top of the pattern for the lead keel to compensate for the wood cut away. This strip should be a little full so that the casting itself will be a little full, which will permit the lead to be trimmed up before fitting to the keel.

It may be pointed out that a good pattern is essential to get a good casting, and the smoother the surface the better. The pattern should, therefore, be glass-papered to a high finish and varnished. The casting of lead keels and their finishing is dealt with in a subsequent chapter. When the lead keel is ready, it must be fitted to the remainder of the keel, but not finally fixed in position.

The spokes which form the keel bolts will have to be cut to the right length. At the bottom end allow about $\frac{1}{2}$ in. more than will be required to come flush with the keel, and bend back to form a loop. This serves as a stop to prevent it being drawn through, and a hole will have to be made in the lead to accommodate the loop. On the top end which goes through to the inside of the boat allow about $\frac{3}{4}$ in. more than will be required to accommodate the full length of the nipple.

Before inserting the spokes they should be thoroughly greased with tallow. The loop must be punched well home below the surface of the lead and the hole soldered over. When screwing the nipple on, it should be put on with the base (or bigger end) downward, and this also should be well greased.

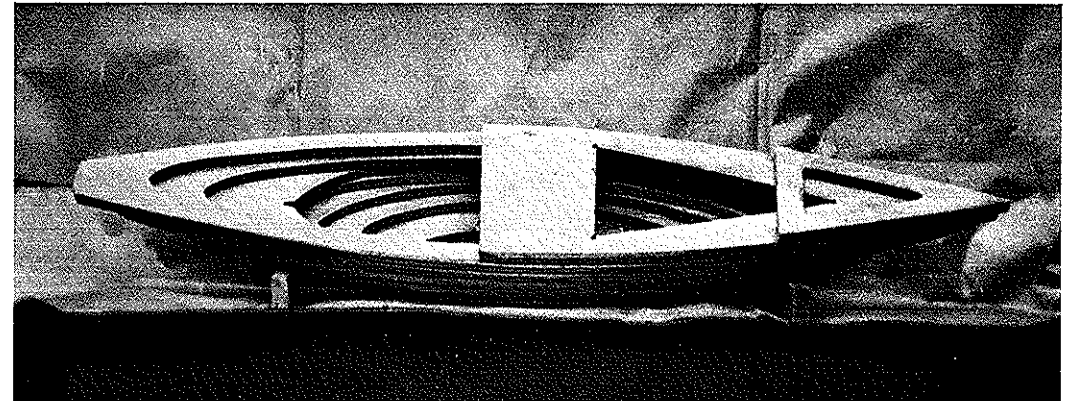
Some builders prefer to fit a removable keel to big boats, such as the A-class, and the procedure in that case is somewhat different. The advantages of a removable keel are that in railway travelling the weight of a boat governs the amount paid on it. On long journeys the difference in freight between 11 or 12 lb. and say 50 lb. is quite appreciable. Again, in travelling, the hull without keel is a far easier thing to handle on a crowded railway platform, and is less liable to strain through jarring. The disadvantages of the removable keel are that unless well made it is apt to get out of truth, and that it is more trouble to construct.

Whichever form of keel is adopted, it cannot be too strongly emphasised that the keel must be absolutely true in a fore-and-aft direction, and perpendicular to the designed waterline of the yacht. The slightest inaccuracy in this respect will make the boat perform differently on the two tacks, and cause the skipper endless trouble when he comes to sail the boat.

The method of fitting a removable keel is given at the end of this chapter. When building a yacht by the bread-and-butter method, it is advisable to make the fin before carving the outside of the hull proper, so that advantage may be taken of the "steps" to square up the keel. This applies equally whether the keel is removable or not.

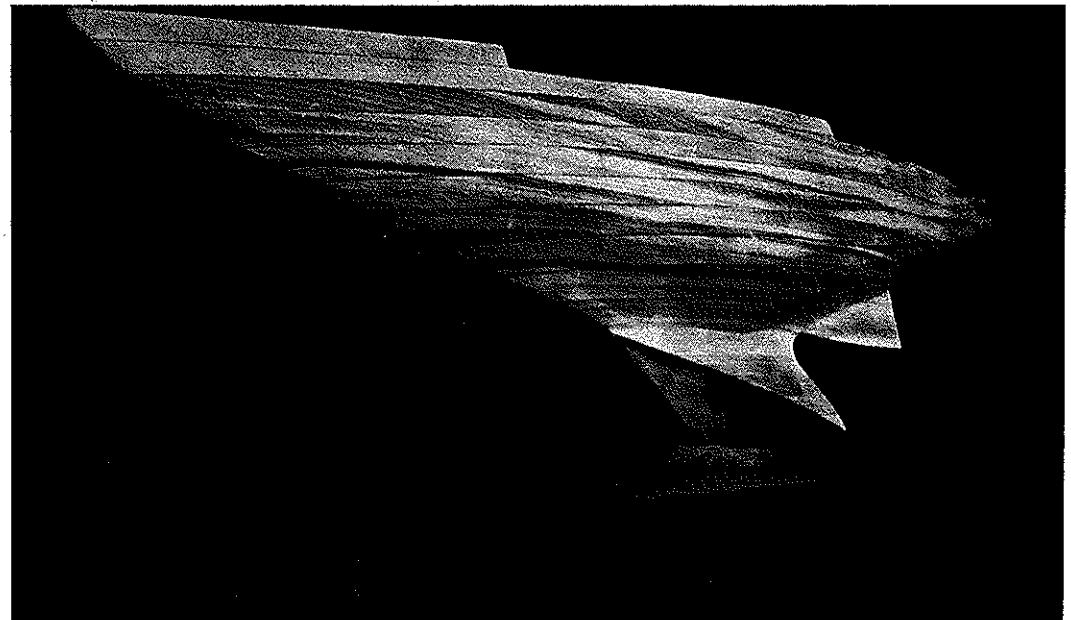
The method of doing this is the same with either a fixed or removable keel. A set-square is used in conjunction with the centreline. The square is placed on the hull and the centreline at each end of the fin carefully checked and adjusted if necessary. The glued joint between the fin and the body of the boat can now be made, using the keel bolts to cramp it up tight.

If the boat is of the fin-and-skeg type, the



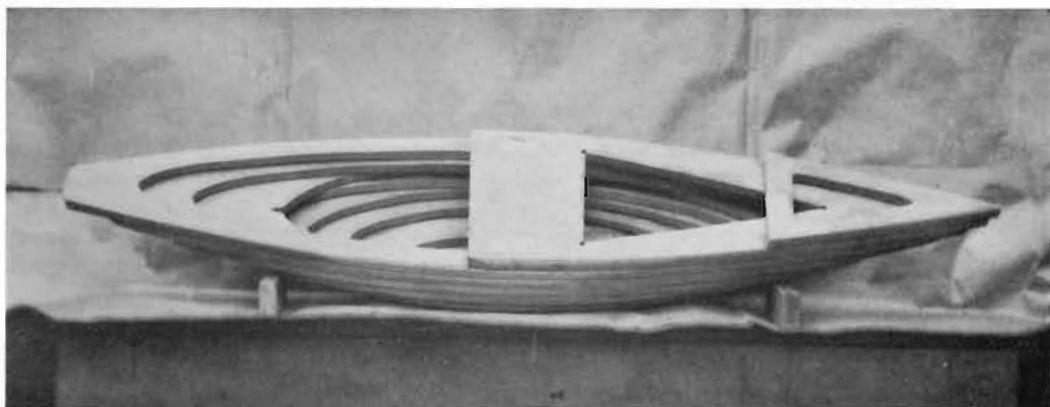
HULL GLUED UP READY TO CARVE.

Note the "steps" inside and outside.

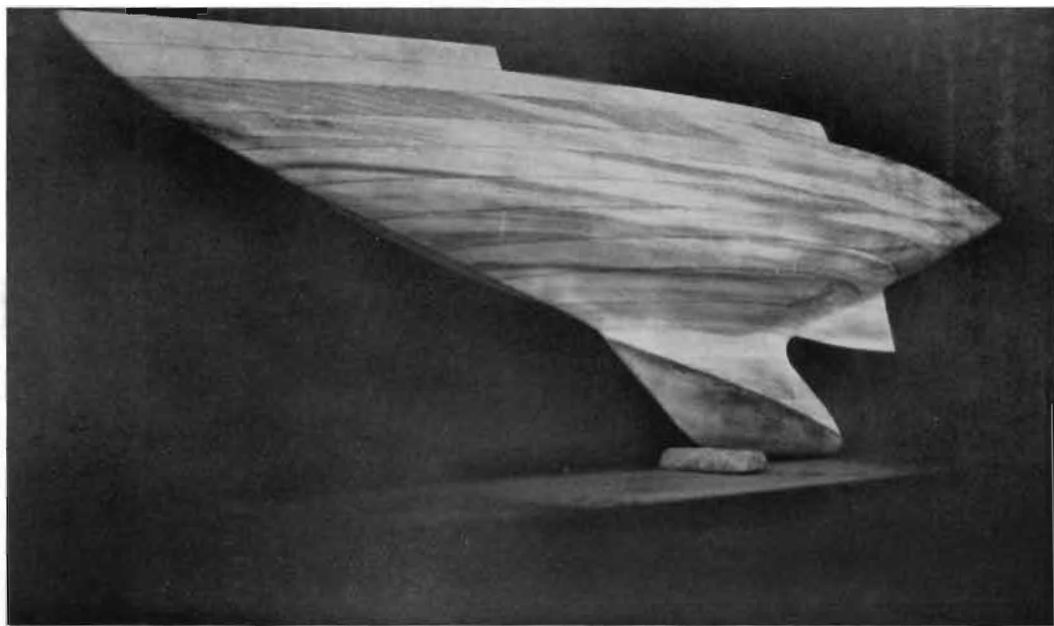


THE OUTSIDE FINISHED.

The next step will be to hollow and cut the sheer. The lead keel has been temporarily bolted into position.



HULL GLUED UP READY TO CARVE.
Note the "steps" inside and outside.



THE OUTSIDE FINISHED.

The next step will be to hollow and cut the sheer. The lead keel has been temporarily bolted into position.

[To face page 100.]

CARVING THE HULL

skeg should also be fitted and carefully squared up in a similar way.

The boat will be easier to handle during carving if the lead keel is taken off, and in any case it will have to be removed when the inside is carved out. Screw the spoke nipples back until they are just above the top of the bolt. Take a punch (or drift) and using a light hammer, tap out until the point when the nipple touches the wood. Unscrew further, and repeat until you are able to withdraw the bolts easily, but take care not to bend them.

The hull can now be set up for carving. Two pieces of wood, about 3 in. wide and 1 in. thick, are screwed on top of the gunwales. These pieces should be about a foot longer than the width of the boat. The boat is then turned upside down and the pieces of wood screwed to the table or bench on which the work is being done. The boat is arranged so that the hull comes just outside the table-top. Most of the hull can be carved away without moving her, but it will be necessary to reverse her for the gunwale on the side near the table. This holds the boat steady and permits both hands to be used comfortably during the work.

Using gouge, plane and paring chisel, the hull of the boat can now be trimmed down to within about $\frac{1}{8}$ in. of the finished shape. The fairing is accomplished by means of glass-paper wrapped round a thin piece of flexible wood.

The final rubbing down should be done with fine glass-paper. It is most important to see that there are no flats or hollows in the surface. This can be tested with a straight-edge, and the hull should be looked at from every angle, both close up and at a little distance, during the final rubbing down. The better the finish that is got on the bare hull, the better will be the result when painted. It is no use relying on paint to cover up rough work. It should be emphasised that glass-papering should be done in the direction of the diagonals and across the grain. A good result will not be obtained by rubbing down in the direction of the grain.

When the hull is properly rubbed down, the glue joints will appear almost as fine as

hair lines. After shaping, the section marks will still be visible on the top of the sheer. Using the uppermost waterline (as represented by the glue joint) as a base, measure off on the sections the height of the sheer. If the deck is to be dropped in, the height will be exactly as shown on the plan. If, on the other hand, it is decided to lay it right across on top of the sheer, the thickness of the deck must be deducted from the height on each section. Through the spots on each section the sheer line is now drawn in, using a spline. It is then cut down with a chisel and finished with glass-paper. The glass-paper should be wrapped round a piece of wood longer than the breadth of the boat, but only round the end in use. By resting the wood across the boat during the operation of glass-papering down, the top of the gunwale will be absolutely square across the yacht. It is very important to fair the sheer up properly, as nothing is more unsightly than a sheer that is not a fair curve.

To cut the sheer and shape the inside comfortably, the boat is removed from the two pieces of wood that were screwed across the gunwales. These pieces of wood are then well wrapped round with pieces of old cloth, to prevent marking the outside of the boat, and again screwed down to the table. Padding should also be placed between the boat and the edge of the table. The boat will then lie in them as in a cradle, with her fin between the pieces of wood. The hull can be held down by a piece of webbing placed across the end that is not being worked on.

The operations of cutting the sheer and hollowing out are carried out more or less simultaneously. A good deal of the superfluous wood from the inside of the upper layers is cut away before the sheer is cut. After the sheer is cut, the inside is finished off. The operations are, however, described separately for the sake of clarity.

The inside has now to be carved out. In order to support the deck, it is necessary to leave a greater thickness along the gunwale (see Fig. 30). If the deck is being fixed on top of the sides the hull should be left about $\frac{3}{8}$ in. thick at this point, and this thicker part should,

extend downward for about $\frac{3}{4}$ in. If, however, the deck is being dropped in, this extra thickness will have to be increased to about $\frac{1}{2}$ in. and extend downward for about $\frac{7}{8}$ in. The extra thickness that has to be left down the stem, under the mast step and round the rudderpost, has already been referred to.

In hollowing out, the wood can be gouged away until down to the grooves. At this point a small round-bottomed fiddle-plane is the best tool to use, and with this the hull is finished down to any required thickness. If the boat is built of pine, the distance from the outside can be judged by holding her up to the light. If it appears very faint and red, you have still plenty of wood left. As the wood gets thinner, the light shows yellow and brighter. If care is taken, there should be no fear of going through the hull.

But if you have the misfortune to go through the hull, the pieces can be glued in place with casein glue, or a suitable piece of wood let in. Chips can be glued on to fill in a thin place.

If all the joints have been properly made, they will be stronger than the wood itself. Before the invention of casein glue, which is waterproof, it was necessary to stitch the joints with copper wire, but this is now quite unnecessary.

In the case of a big boat, such as an A-class, which has a very heavy keel, some builders fit floor timbers extending from bilge to bilge, to take the weight of the keel. In the case of a hull which has been built exceptionally light, particularly if it is fitted with a removable keel, it might be an advantage to fit two to take the main keel bolts. This is, however, certainly unnecessary in any smaller boat. If fitted, the floors are glued and screwed through.

Some builders use the alternative method of building bread-and-butter fashion on the buttocks instead of on the waterlines. This, of course, applies to the canoe body only, and the fin keel is built up bread-and-butter on the waterlines as usual.

For building on the buttocks, the latter must

be spaced not more than 1 in. apart, and, if necessary, buttocks will have to be taken out at suitable intervals. In any case, however, the centre layer must be arranged so as not to have a joint up the centreline of the ship, as this would be bad engineering, since the bolts carrying the heavy lead keel would then fall on a joint. Thus, if the layers were being made 1 in. thick, the buttocks would fall at $\frac{1}{2}$ in., $1\frac{1}{2}$ in., $2\frac{1}{2}$ in., $3\frac{1}{2}$ in., etc., cut from the centreline. As this is a bit awkward, it is a better plan to make the centre layer double thickness (2 in.) so that the other buttocks are more conveniently spaced.

The advantages of this system are very great economy of wood, and the fact that the backbone of the yacht is in one piece. Against this, the hull is somewhat more difficult to shape, and the beginner will probably find it easier to build on the waterlines.

If a 2 in. centre layer is used, considerable economy might be effected by building up the centre layer in three pieces, rather after the fashion used to build the backbone of a planked model (see Fig. 54). This will make a considerably stronger job also, as the grain of the wood up the stem will run correctly instead of being an end grain as in any other form of bread-and-butter hull.

The down-thrust of the mast in an A-class boat is very considerable, and unless precautions are taken to counteract this, trouble is almost certain to follow. An internal stay (or brace) must, therefore, be fitted from the keelson, under the mast step, to the gunwales, to take the pull of the shrouds. For this purpose some builders use a piece of $\frac{1}{8}$ -in. half-round brass strip. This is let into the keelson under the mast-step and firmly screwed down. The ends are carried to the gunwales, into the top of which they are sunk and screwed. The ends of the strap are bent over sharply to lie flat on top of the gunwale, and the screws driven straight downward. The strap is bedded into the hull with white-lead paint.

Another method of effecting the same result is to use a wire instead of the strip brass.

Either is equally efficacious, and the wire is lighter (see Fig. 52).

The deck-beams must now be fitted, also the rudder-tube, as explained in due course. The inside of the hull must receive three coats of varnish. Of these, the first coat should be varnish and turpentine mixed in equal parts. This causes it to sink well into the wood. The second and third coats are pure varnish.

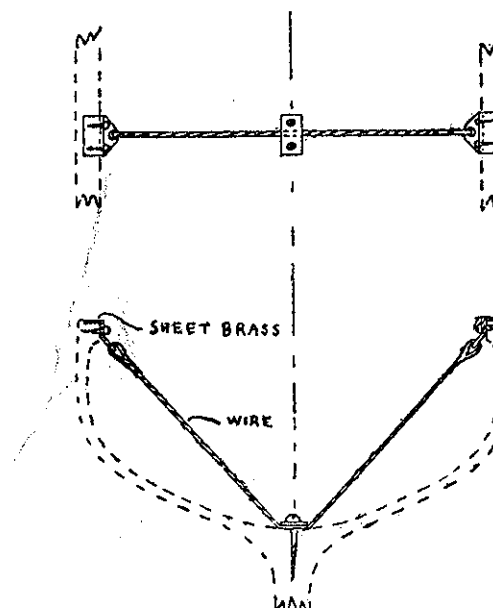


FIG. 52.—INTERNAL BRACE TO TAKE PULL OF THE SHROUDS.

When the hull is dry, the mast-step is fitted into position.

In order to facilitate carrying, a handle is fitted to the bottom of the boat, immediately under the hatch. This can conveniently be made of stout leather, and can be held into place by the nipples on the keel bolts. The handle should be sufficiently large to allow of a comfortable grip, and should be arranged to come immediately over the centre of gravity of the yacht. A badly-balanced boat is far harder to carry. Another point which is worthy of consideration is that if the handle

is too low in the boat, the edge of the hatchway will take against the wrist in carrying. In a small boat this is a matter of no moment, but in a boat weighing nearly $\frac{1}{2}$ cwt., it makes a considerable difference to the skipper's comfort, and a handle coming just under the hatch is very convenient. This is easily arranged by using a wooden handle of suitable size to fit the hand and fixing the ends by stout copper wire, using several strands. The wire is made fast to the top of the keel-bolts by the nipples, and, being flexible, allows the handle to be pushed aside to bail the boat, or for any other purpose, when it is in the way.

If a leather handle is used, this must be renewed every two or three years. Leather under the action of water, particularly salt water, rots in time, as the oil and dressing dry up. Do not wait until the handle actually breaks as the boat may be dropped and badly damaged, but inspect the handle occasionally and renew at the first sign of perishing.

If it is desired to fit a detachable keel, this must be arranged for early in the building. If possible, the keel should be arranged to take off straight across the boat at a waterline just below the hull itself. This will enable the hull to be handled conveniently and stand level when it is put down. If the boat is of the fin-and-skeg type, the joint should be below the bottom of the rudder, if possible, to avoid injury to that important part. In order to take off parallel with the L.W.L., part of the deadwood will have to come away with the lead.

Instead of using four keel-bolts, two of a much stouter gauge will be required. The keel-bolts will be made from $\frac{3}{8}$ -in. brass rod. In order to keep the lead and the removable part of the deadwood together, a stop must be braised, or hard soldered, to the rod at such a level that it will just come below the surface of the deadwood at the joint. The bottom end of the bolt is threaded up for about $\frac{1}{2}$ in. and fitted with a nut. The keel is recessed so that, when screwed home, the nut will be just below

DETACHABLE KEELS.

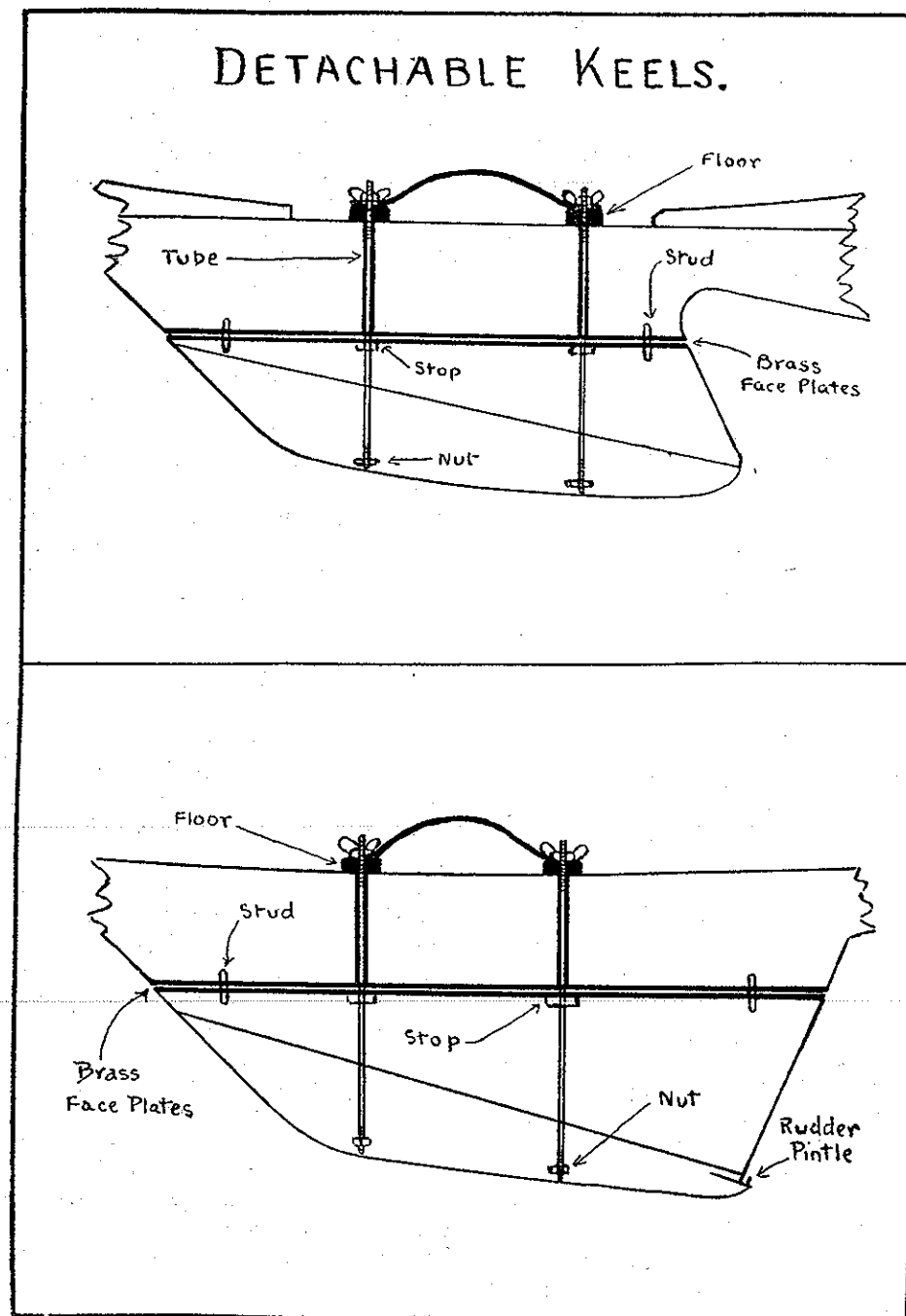


FIG. 33.

FITTING A DETACHABLE KEEL

the surface of the lead, and the bottom of the keel-bolt cut off accordingly. The two faces of the keel at the joint will have to be brass, but this will be put on later.

The first step will be to get the keel made and assembled with the lead. The holes that are bored through the hull will have to have a brass or copper tube through them of an internal bore that *just* clears a $\frac{3}{16}$ -in. rod. If floors are to be fitted in the boat, the tube should be left sufficiently long to allow for the tube reaching through the floors. The rods forming the keel-bolts should be left of such a length that they will protrude about $\frac{3}{4}$ in. through the tubes into the boat. The top ends of the keel-boats have to be threaded down about 1 in. and brass butterfly nuts fitted. Until the floors are fitted it is wise to put a piece of wood with a hole to act as a washer and prevent the tubes being withdrawn by the weight of the keel. The tubes are only temporarily inserted at first, and can be withdrawn during the operation of cleaning up the inside of the boat. When all is ready, inside and out, and the floors (if any) in position, the fitting of the brass keel faces can be attended to. Two strips of brass are cut, and two holes bored of the right size to clear the keel-bolt tubes in the upper one and the keel-bolts in the lower one. The hull is now turned upside down, and the upper face put into place temporarily. The lower face is then put into place and two pieces of rod passed through the holes into the tubes to make sure it registers exactly.

The next step is to fit a stud at each end of the keel to prevent it wringing. The importance of keel alignment has already been stressed. It will, therefore, be sufficient to say that the fitting at this point must be extremely carefully done.

After making sure that the two faces register perfectly, remove the lower face, and with a scribe lightly mark in a centreline. At a suitable distance from each end, which will entirely depend on the thickness of the keel, make a punch mark on this centreline. Replace the face, and using the punch marks, drill right through the two faces and about $\frac{1}{2}$ in.

into the wood of the hull. Both faces are now removed, and wood planed away from the bottom of the hull to twice the thickness of the brass. The brass face is now replaced and marked round with a scribe and cut just outside the line. The face is now replaced on the hull, being bedded in white lead. The tubes are similarly bedded and put finally into position. The brass face is drilled and fastened with brass screws to the hull. The face can be now trimmed down with a fine file. The inner end of the tube should be slightly belled outward, to fix it firmly into the bottom of the boat or floor, as the case may be.

The bottom face has now to be attended to. Place the bottom face in position on the detachable portion of the keel and drill holes into the wood to take the studs. Mark round with a scribe, remove and cut to shape. As the thickness of the brass has been allowed for already, there will be no need to remove more wood. Two pieces of brass rod are needed to make the studs. These should be $\frac{3}{4}$ in. long and of a size to fit the holes in the face plate. These should be hard-soldered into the face plate with $\frac{1}{2}$ in. below the plate and $\frac{1}{4}$ in. above. The upper ends can be rounded off slightly, but not down to the plate. The face is now replaced and fixed into position. It is then trimmed off exactly. The keel can now be tested, and if all has been accurately carried out, should fit exactly.

If necessary, the holes for the studs in the hull can be eased in the wood, provided the brass remains a good fit; but if it is necessary to do this, the brass should be removed whilst so doing. The studs remain permanently in the holes in the detachable part of the keel, and can be bedded there in white lead. In order to protect the wood in the upper part, the holes should be well doused with oil, which will soak into the wood. The bolts and studs should themselves be well oiled before putting together, to obviate sticking. Under the butterfly nuts a leather washer with a metal washer on top will obviate any leakage. The handle can be put on to the keel bolts if desired, but this will mean that with the keel off there is no handle to carry the boat. Alter-

MODEL SAILING CRAFT

natively, it can be secured to the bottom of the hull and well screwed down. In that case it is best to have the handle between the keel-bolts, so as to be out of the way when it is desired to adjust the keel-bolt nuts.

The whole arrangement is shown clearly in Fig. 53. The top drawing in this figure represents a planked model with a fin-and-skeg keel, and the lower one a bread-and-butter model with a full keel.

THE methods of planking a model yacht in the main follow real yacht practice, but, naturally, there are certain minor differences due to the difference in size.

Yachts are built either on cut timbers or with bent ribs, or a combination of both. The cut timbers in a real yacht are formed from natural crooks (or bends), and in the old days a shipwright used to set great store by his stock of oak crooks. To-day, the use of cut timbers is almost entirely confined to fishing-boat work. In models, bends are not available, and therefore this form of construction would be very weak, owing to the fact that some part of the cut timber (or frame) would be across the grain. To get the necessary strength, very heavy frames would have to be used, so that the method cannot be recommended. Its one advantage is that it dispenses with the use of moulds, as the frames answer the purpose of moulds also. Some model builders use three-ply, or even five-ply, to make their frames, but apart from the fact that plywood is not suitable for most yacht or model work, this is very bad engineering, as the fastenings are put edgewise into the plywood in such a way as to tend to force the layers apart. It is, therefore, best to use bent timbers throughout.

There are two main systems of building with bent timbers. The first is to bend the timbers on to the moulds and plank up on these. Some builders treat these timbers, which are bent on to the moulds, as main ribs, and when the boat is planked up, bend additional ribs of lighter scantling into the boat in between. Others do not put any extra timbers into the boat, but trust to those originally put in.

The second method of planking on bent timbers is to build a former over the moulds and bend very small timbers over this at close intervals and plank up on these. This is the best method of all, as a stronger and lighter

CHAPTER XII

The Construction of Planked Yachts. Various Systems Explained. Making the Moulds and Setting Up. Planking Up.

hull will result. It takes slightly longer, but the result is well worth while.

In building a large wooden vessel, the practice is to lay the planks with a slight gap between, into which caulking is forced with caulking chisel and mallet. This allows for the wood swelling as it gets wet, and a vessel is said to "take up" until she becomes tight. In smaller constructions, a single thread of caulking cotton is laid between each plank during the building. In smaller work still, nothing is put between the planks. Canoes and similarly finely-finished light craft rely entirely on the good fit of their planking. In models, which can be adequately protected against the damp reaching the wood, and kept entirely rigid so that they do not work, the best plan is to make the planks a good fit and glue them edge-to-edge with casein glue. This practically makes the model one piece of wood from gunwale to gunwale. Some builders prefer to use thick varnish, and put the planks on with their edges luted with this.

Whichever system is to be employed, the first step is to get out a full-size profile and section plan of the yacht. The method of doing this was explained in a previous chapter.

It will now be necessary to decide how far down the planking is to be carried. Some builders like to plank down nearly to the lead, in imitation of the real yacht, but this is unnecessary labour, from which nothing is gained. The real yacht is, of course, hollow right down to the keelson, but if a model were hollowed down proportionately low, it would be impossible to dry her out.

The first thing to decide is, therefore, how far down the hull is to be planked, and below this point the fin (or keel) will be built in layers bread-and-butter fashion. Thus the top layer of the bread-and-butter keel forms the keelson. A study of Fig. 54 will make this clear. In deciding how far down the planking is to

MODEL SAILING CRAFT

extend, a point to remember is that the reverse turn of the garboard is the most difficult part of the yacht to plank, but the real deciding factor is the width across the sections in this part of the boat.

Having decided where the keelson is to come, it will be necessary to draw the backbone in on the full-sized profile. The fin and backbone can be of pine, cedar or mahogany, but the two former are preferable on the score of weight. If it is intended to paint the boat all over or up to the waterline, pine is preferable for the fin. If she is to be varnished on the lower part, it must be cedar or mahogany.

The forward part of the backbone will have the stem incorporated with it, and on the score of strength, mahogany is best. The after part of the backbone can be of pine, cedar or mahogany. The same considerations will govern the choice of material, as for the keelson.

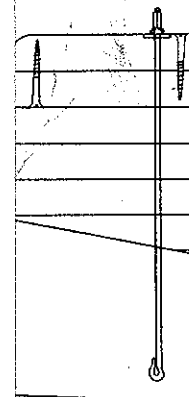
The forward part of the backbone for an A-class model will be made of 1-in. wood, and its depth (or moulding) will depend on the size of the boat and the shape of the bow waterlines at the particular point. The actual stemhead of a boat of this size will require to be about 3 in. from back to front. It must be remembered that a boat of the A-class weighs anything up to 56 lb., and in the case of a collision the force of the blow on the stemhead is very considerable.

The after part of the backbone can be cut from 1-in. wood, but need not be made so strong, and also the shape of the forward waterlines is more acute than those aft. About an inch will be enough for the siding and $\frac{3}{4}$ in. for the moulding of most of this afterpart. It must be borne in mind that there must always be a sufficient depth of wood from side to side to fasten the planks and take the two rabbets in which the plank-ends are housed. The wood which is left must also be sufficient to ensure a reasonable margin of strength. This will largely govern how far the garboards are carried out at the ends, and the construction of this part of the boat requires to be carefully considered. In a keel-type boat, this will apply particularly at the after end of the keel.

After putting in the backbone on the profile drawing, a datum line must be struck on the plan to show the building-board. This should be about an inch above the stemhead, and parallel to the L.W.L. It is very essential that the building-board should be rigid, and for an A-class or other large model it will be wise to make the building-board in the form of a T-girder. Two pieces of hardwood, 4 in. wide and about an inch thick, will be required. The board should be about 6 in. longer than the overall length of the boat. This piece is used as the base proper, and the other piece of wood is screwed underneath it. The upright part of the "T" can then be gripped in the vice during building, and the model held securely. The strains during the building of a big boat are considerable, and this method of making the building-board is strongly to be recommended. Obviously, if the board twists, the model will go out of shape. The building-board will have to be very carefully planed up and squared, so that the moulds may be erected correctly in their proper alignment.

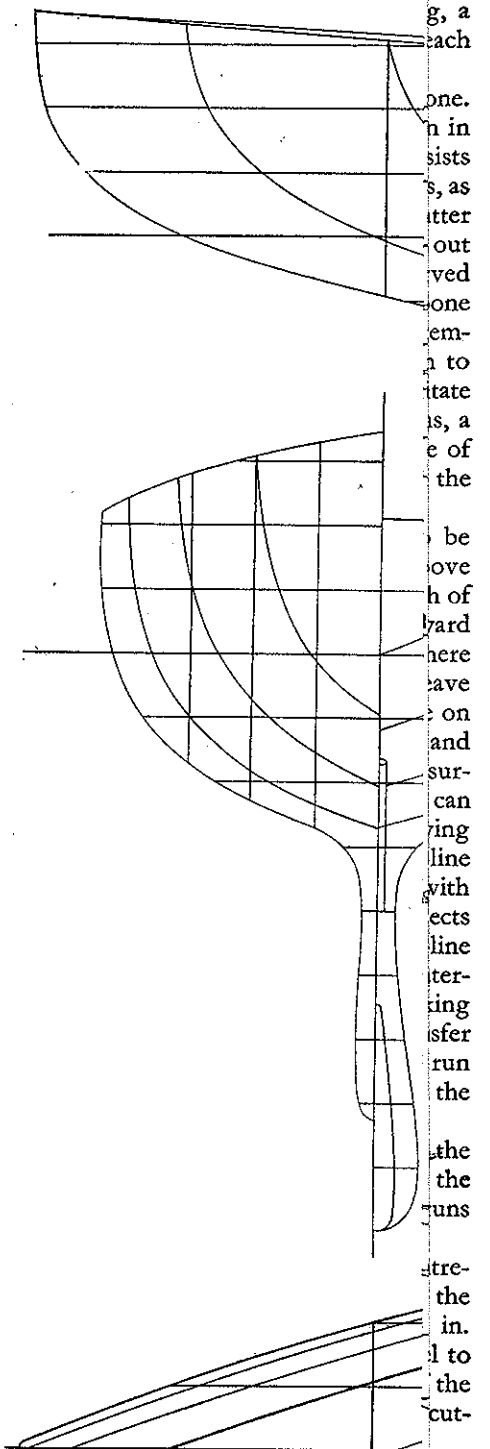
The moulds have next to be prepared. The full-sized section plan is laid over a sheet of fairly stout cartridge paper and the section pricked through. Centreline, buttocks and waterlines must also be marked in. The half section so found will have to be drawn in with a flexible spline and a sharp pencil. By folding the paper up the centreline and cutting out the double thickness, the whole section will be obtained and both sides will be alike. The shape can be checked after cutting by laying it on top of the full-sized section plan.

Obviously, if the moulds were made the size of the sections, the boat would be increased by the thickness of the ribs and planking. It will, therefore, be necessary to reduce the paper template from which the mould is to be made by an amount equivalent to the thickness of the planking and ribs. If the alternative method of building over a former is being used, the thickness of the battens which compose the former will also have to be taken into account. For example, if the planking is to be $\frac{1}{8}$ in., and the ribs are to be $\frac{1}{8}$ in., the amount to be taken off will be $\frac{1}{4}$ in. If the



ND-PLANK BUILDING
ed into place, also I
described in text.

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SCALE: ONE-THIRD OF FULL-SIZE.

Folding Plate XII.]

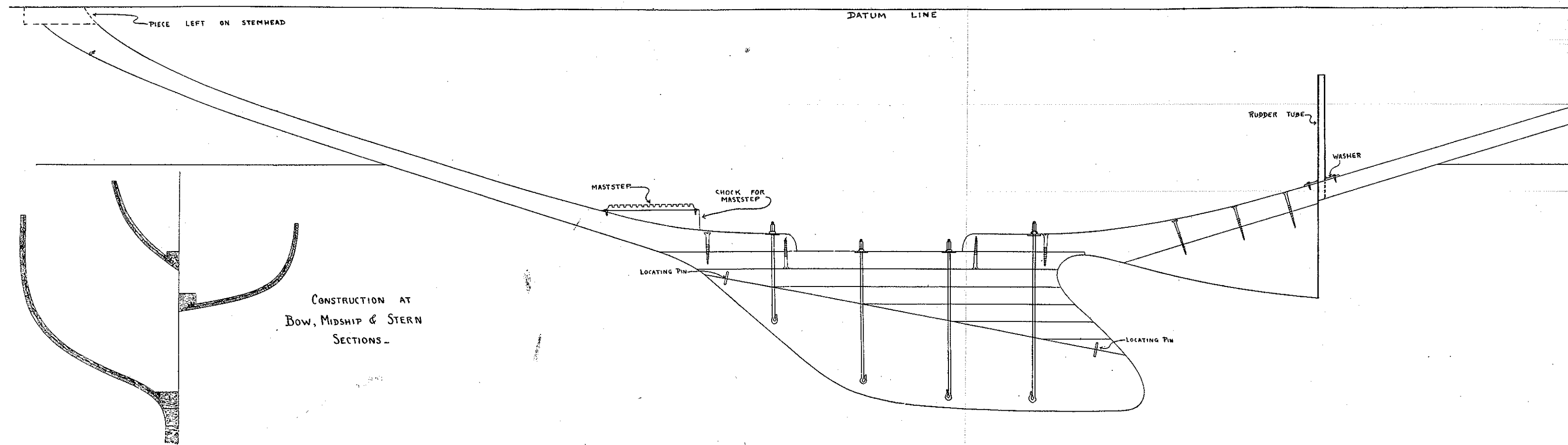


FIG. 54.—CONSTRUCTION PLAN SHOWING SYSTEM USED IN RIB-AND-PLANK BUILDING.

Backbone of model yacht showing method of building up in three parts with fashion piece attached. Backbone is shown with fin built up and lead keel bolted into place, also piece left on stemhead and packing pieces at stern as required to fix on to building board. Mast step (mounted on chock screwed to backbone) and rudder tube are shown in position, though the latter is not fitted until shell of boat is completed, as described in text. The "Datum Line" shown represents the building board which can be considered as the stocks on which the craft is built upside down. The smaller diagram shows three sections at various stations in the boat, and illustrates the way the ribs are checked into slots in the keelson, and the manner planking is fitted into rabbet.

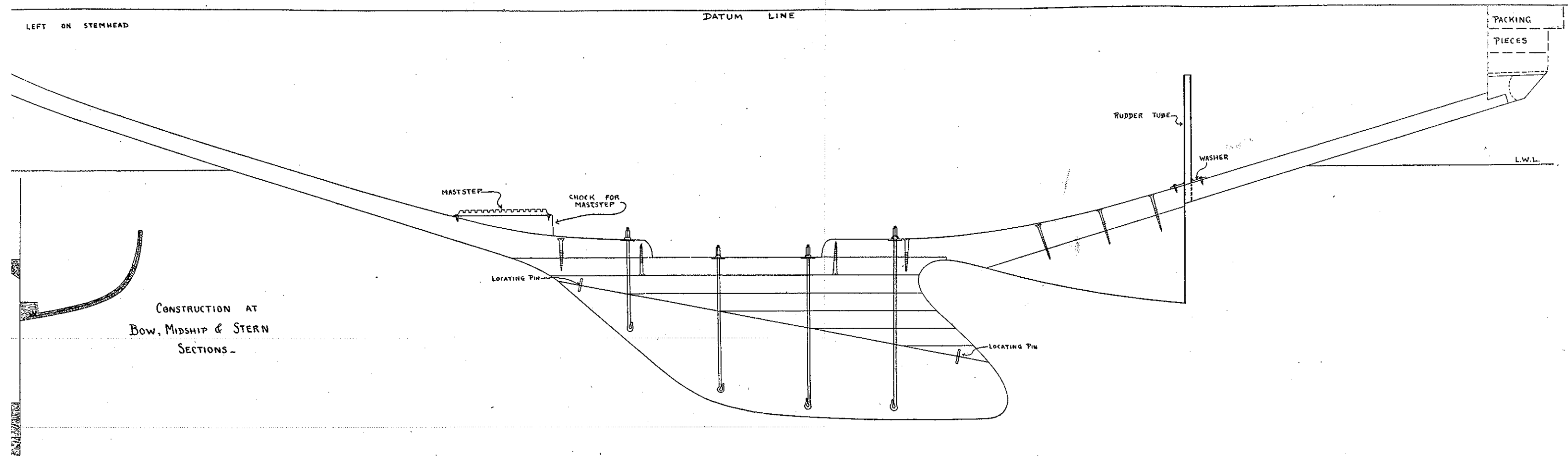


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SETTING UP THE MOULDS

method of building on a former is being used, the planking might be $\frac{1}{8}$ in., the ribs $\frac{1}{16}$ in., and the battens in the former $\frac{1}{8}$ in., so that the amount to be taken off in this case would be $\frac{5}{16}$ in. Lines will have to be drawn parallel to the outer skin, and the size of the paper patterns reduced accordingly. The best method of doing this is to use a small pair of dividers, preferably a spring bow, and set them to the required distance.

As the fin will be built up solid, the moulds in the centre part of the boat will only be required to come down to the keelson. At the ends, it will be necessary to carry the patterns down the full depth and then slot them in the centre to receive the backbone.

The top of the paper patterns should be carried right up to the datum line, as the moulds are to be mounted on the building-board which this represents.

Similar paper patterns, complete with buttocks and waterlines, are made for every section. They are then pasted on to suitable pieces of whitewood, $\frac{1}{4}$ in. thick, and the moulds cut out just outside the paper, and trimmed down sharp to the outline.

The boat is to be built upside down on the building board, and the next step is to set up the moulds. This is done exactly as was described in the chapter on Building a Sharpie. A centre-line is struck on the building-board, and the station lines for the sections carefully squared off. Pieces of wood 1 in. square are screwed to the building-board to hold the moulds in position. The midships section has to come, with its centre on the station line. The cross piece will, therefore, have to be fixed $\frac{1}{8}$ in. away from the station line. The forward moulds have their after faces on the station, and consequently the cross pieces for these must have their fore side on the station line. The after moulds have their forward faces on station, and the cross pieces for these will, therefore, have their after faces on the station lines. The screws holding these cross pieces in position must be put through from the underside of the building-board to permit their removal when the hull is completely planked up.

In order to prevent the moulds shifting, a couple of battens are lightly tacked along each side of the boat.

The next step is to prepare the backbone. This is made up in several parts, as shown in Figure 54. The middle part, which consists of the keelson, is laid off from the waterlines, as explained in the chapter on Bread-and-butter Construction. After this has been marked out on both faces, it is cut out and carefully carved to shape. The forward part of the backbone is now marked out from the plans. The stem-head must be made long enough to reach to the building-board, and in order to facilitate screwing to this during building operations, a tab of wood should be left on the foreside of the upper continuation. This is shown in the diagram.

Now the planking of the yacht has to be rabbeted into the stem. The rabbet (or groove in which the plank-ends lie) is the full depth of the thickness of the planking at its forward edge, and gets shallower until the point where it comes to the surface and the planks leave the groove. The front edge of the groove on the stem is known as the "rabbet-line," and the point where the groove comes to the surface as the "bearding-line." Both of these can be determined from the plans by the following method. On the waterline plan draw a line representing the width of the stem parallel with the centreline. The point this line intersects each waterline is the position of the rabbet-line on this particular waterline. Now if the waterlines have been put on the stem, when marking out for cutting, it is an easy matter to transfer these points to the stem. A line is now run through them following the contour of the stem.

For the bearding-line set the dividers to the thickness of the skin planking, and find the spot on each waterline where the planking runs to the surface of the stem.

Next with the marking gauge put a centre-line down the foreside of stem. With the marking gauge put in two more lines $\frac{1}{16}$ in. on either side of the centreline and parallel to it. This gives a cutwater $\frac{1}{8}$ in. wide, and if the wood between the rabbet-line and the cut-

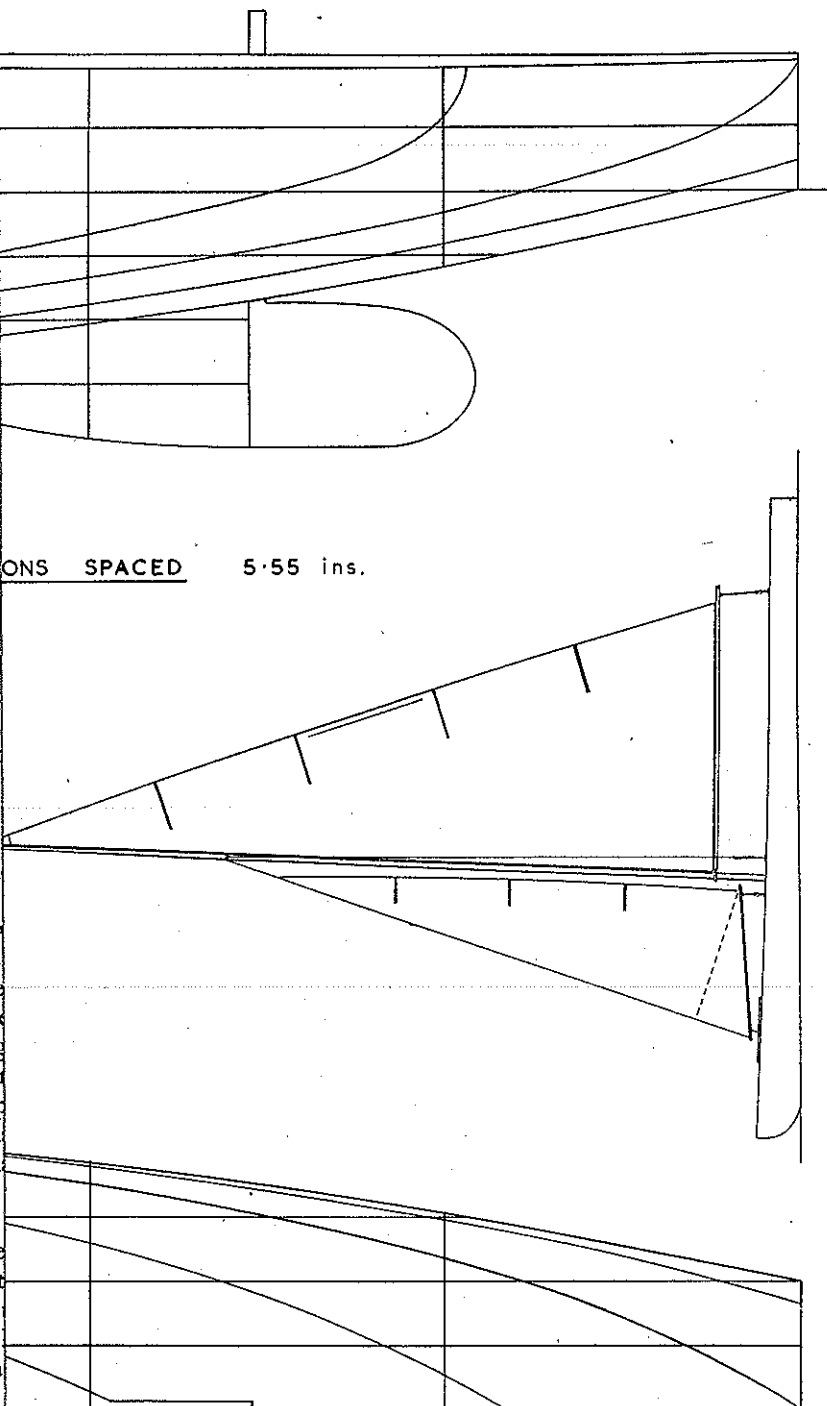
extend, a portion of the turn of the of the yacht factor is the part of the l

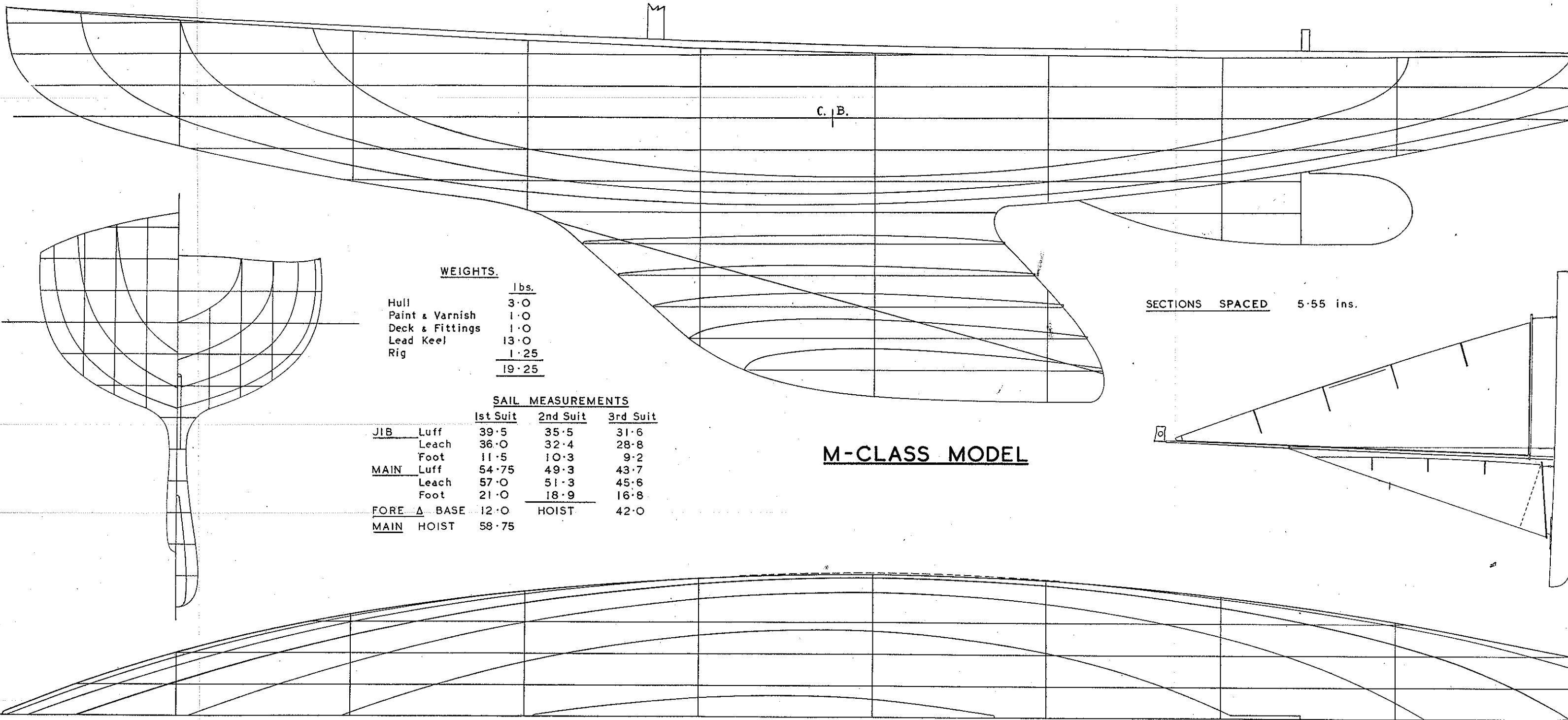
Having come, it will bone in on backbone can but the two of weight. over or up for the fin. lower part,

The forward the stem in of strength, of the back mahogany. govern the keelson.

The forward A-class model and its depth the size of the waterlines at stemhead of be about 3 in remembered anything up collision the is very consid

The after from 1-in. v strong, and a lines is more inch will be the moulding be borne in sufficient depth fasten the pl which the pl which is left a reasonable largely governed carried out at this part of considered. particularly a





WEIGHTS.

	lbs.
Hull	3.0
Paint & Varnish	1.0
Deck & Fittings	1.0
Lead Keel	13.0
Rig	1.25
	<u>19.25</u>

SAIL MEASUREMENTS

		1st Suit	2nd Suit	3rd Suit
<u>JIB</u>	Luff	39.5	35.5	31.6
	Leach	36.0	32.4	28.8
	Foot	11.5	10.3	9.2
<u>MAIN</u>	Luff	54.75	49.3	43.7
	Leach	57.0	51.3	45.6
	Foot	21.0	18.9	16.8
<u>FORE</u>	<u>Δ</u> BASE	12.0	HOIST	42.0
<u>MAIN</u>	HOIST	58.75		

SECTIONS SPACED 5.55 ins.

M-CLASS MODEL

SCALE: ONE-THIRD OF FULL-SIZE.

Folding Plate XII.]

[To face page 109.

MODEL SAILING CRAFT

water is carved away, the fore part of the stem will be correct to shape. The rabbet can now be cut out. It will facilitate this operation if a slip of the planking wood is used as a gauge for the depth.

The after part of the backbone is similarly cut out and shaped, and the rabbet cut. It should be noted that as the after waterline endings are not so acute an angle as those forward, the method of marking the rabbet-line as detailed for the stem does not apply, but the builder will not find any great difficulty on this score. It will be noticed that on the Construction Plan (Fig. 54) the after part of the backbone butts on to the centre part. The object of this is to leave sufficient wood to carve away when the skeg is fitted, and thus obviate a hard angle at the junction of these parts of the structures and permit the round of the garboard to be continued up to the rudder tube. The skeg should now be fitted. These parts are now carefully glued and screwed into position on the keelson. The greatest accuracy is needed to get these correctly aligned, as if they are the slightest bit out, the boat will be out of truth and sail differently on the two tacks.

The fashion-piece has now to be made. Taking a piece of cedar or mahogany of the correct size, draw a centreline in the direction of the grain. On this top face set out the deck-line at this point. For the benefit of the tyro it may be explained that the "fashion-piece" is the extreme stern of a boat with a counter. The board across the end is known as the "transom." The centreline must be carried right round the block of wood that is being used for the fashion-piece. The fashion-piece for an A-class boat will have to be the fore-and-aft distance covered by the rake of the transom plus 1 in. Upon the forward vertical face of the wood lay off the section of the boat at that point, and upon its after face the section that would have been made had the boat finished with a vertical transom. Care must be taken to give the deck the proper camber on the after end. Starting with the bottom face, the block is now carved to shape. A rabbet has next to be cut to allow the planking

to lie flush. Finally, a slot must be cut to allow the backbone to be checked into it, and two slots to house the ends of the inwales. The fashion-piece is now fitted to the backbone with glue and two brass screws which are placed in the rabbet, where they will eventually be hidden by the planking.

By referring to the profile plan, it will be seen that the fashion-piece will not reach the building-board. A suitable piece of wood must be cut and screwed to the top of the fashion-piece to pack it up the correct distance from the building-board.

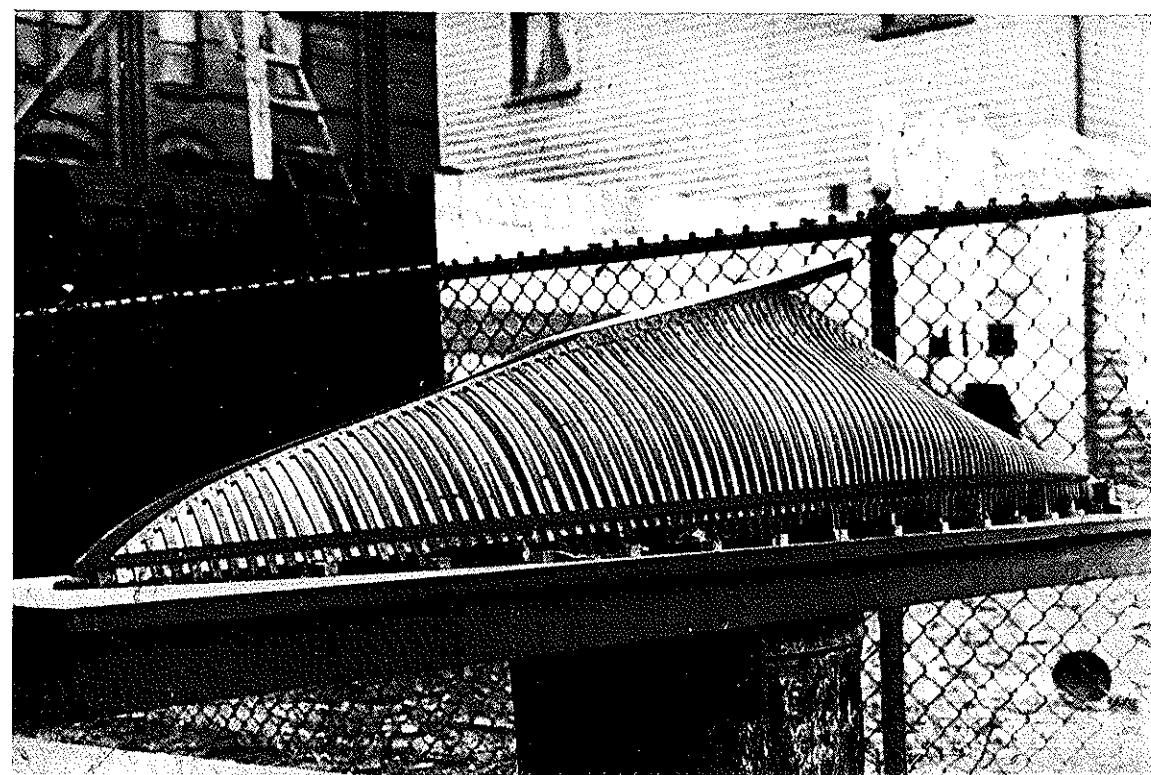
The backbone is now ready to be dropped into place in the slots along the moulds. The stem and stern are secured with screws to the building-board. Before proceeding any further, again carefully check over all the moulds, and see by the buttocks and waterlines that they are in perfect alignment.

The importance must also be stressed of getting the various parts of the backbone in perfect alignment, and setting up the backbone dead square to the building-board. The proper alignment of the backbone and moulds is the most important thing in building a planked hull, as otherwise a twisted hull will result.

If the rabbet for the garboard has not been cut along the keelson, this must now be done. As the keelson is already shaped, there will be no difficulty in doing this, especially if a slip of the wood for the planking is taken for a gauge of the depth. The slots to house the ends of the ribs must also be cut in the keelson. As the planking has to lie flush in the rabbet, the slot must be sufficiently deep to permit the rib to drop down level with the bottom of the rabbet. Provision has to be made for the rib to have a good holding on the keelson, and the slot should allow the rib to come at least $\frac{3}{8}$ in. on to the keelson. The planking should extend below the ends of the ribs, so that the rabbet-line will have to be at least $\frac{1}{2}$ in. below the upper face of the keelson.

Up to this point the procedure has been exactly similar, but if the boat is to be built over a former, it will now be necessary to make this. The former (or jig) is made of strips of wood about $\frac{1}{2}$ in. wide and exactly $\frac{1}{8}$ in. thick. The

"YANKEE DOODLE" (A-CLASS), BUILT BY A. E. BULL, U.S.A.

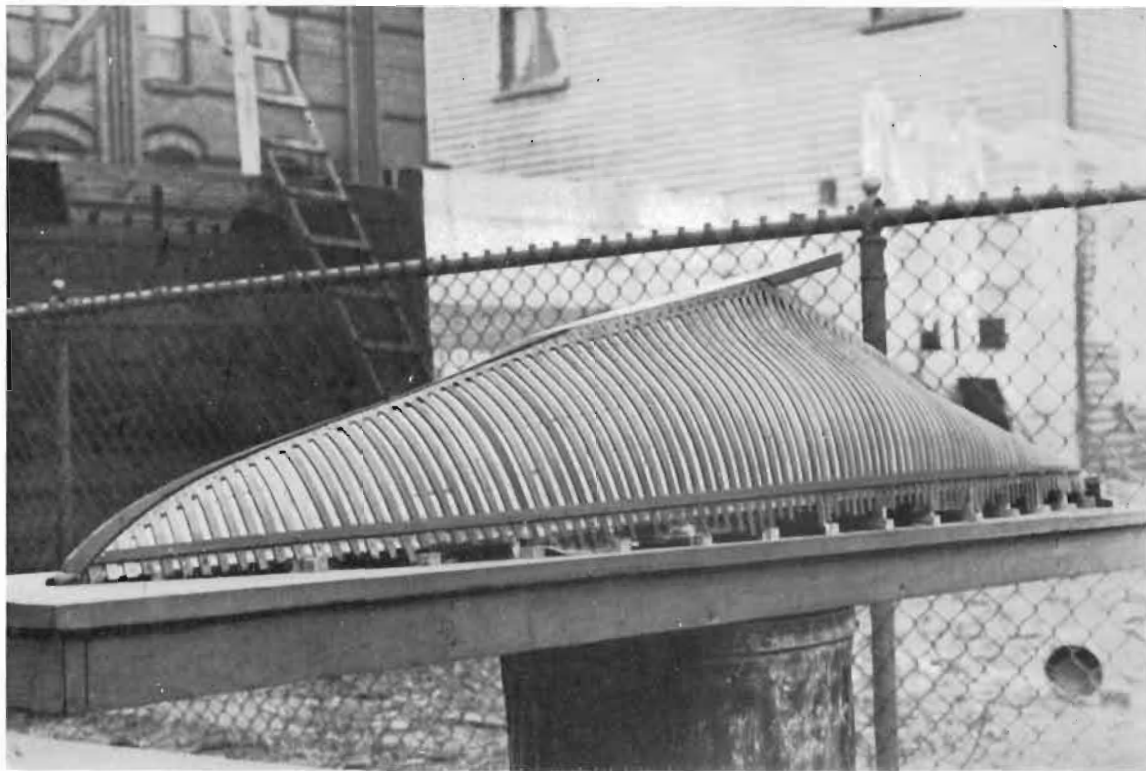


THE BOAT IN FRAME.

Note the planking rabbet down the stem and the sheer strake tacked into position. The building board used by Mr. Bull is wider than that suggested in this book, but there is no great advantage either way except that the narrower board uses less wood and is possibly easier to handle.

The excellent photos of "Yankee Doodle," "Polka Dot" and "Claire" which illustrate this chapter were supplied by Mr. A. E. Bull, the well-known American builder and model-yachtsman.

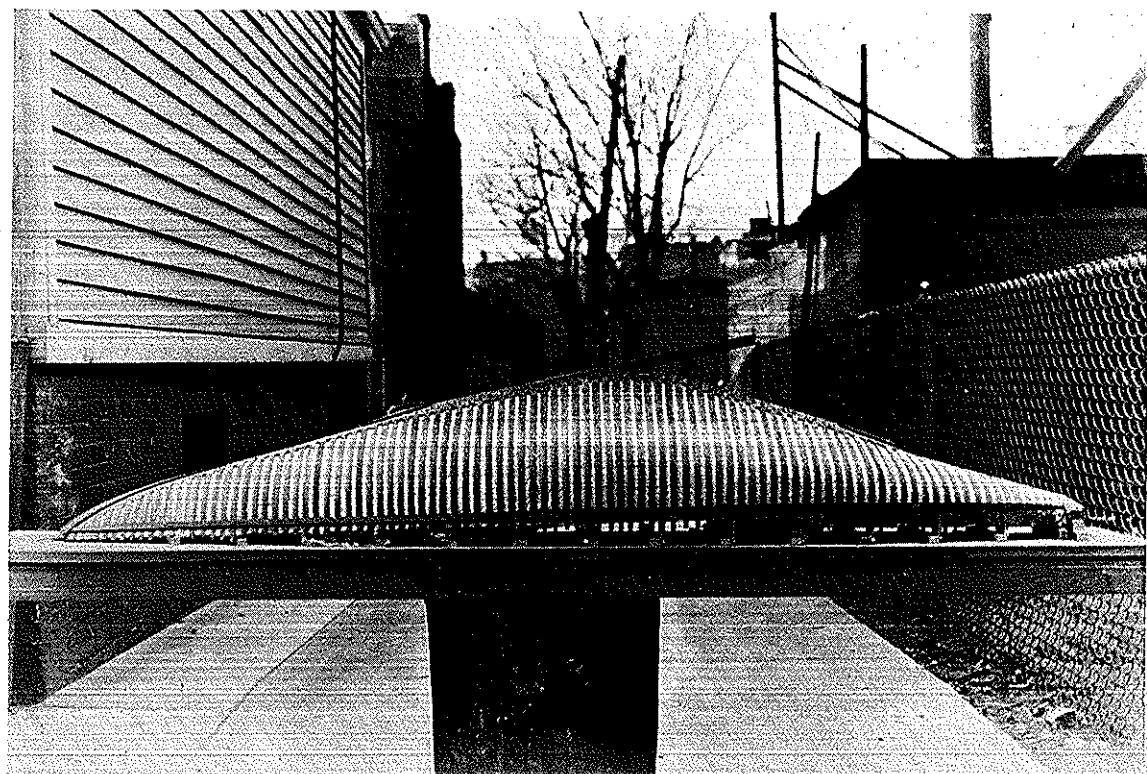
"YANKEE DOODLE" (A-CLASS), BUILT BY A. E. BULL, U.S.A.



THE BOAT IN FRAME.

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ANOTHER VIEW OF "YANKEE DOODLE" IN FRAME.

The completed boat is shown in the photographs facing page 114.

[To face page 111.

BUILDING ON A FORMER

thickness is a matter of moment, as it must be the same as allowed when taking the thickness off the patterns for the moulds. It is not of any importance that these battens should be in one length from end to end of the boat. Their sole purpose is to form a frame over which the ribs can be bent to shape. On the sides where the section is more or less vertical, larger gaps can be left, but round the bilges and in the reverse turn of the garboard the strips should be fairly close together. When these strips are offered to the moulds, it will be found that they only touch the forward moulds on their forward edges. Similarly, on the after moulds, the strips will only touch the after edges. The moulds will, therefore, have to be rubbed down till the strips take properly right across each mould. At this point it can be seen that all the curves are fair. If anything requires adjusting, this must be done now. The strips should take on every mould without having any flats or humps, and, if necessary, any section mould must be padded out or reduced. If a properly-drawn design (such as those that accompany this book), has been used, and care taken in its enlargement and laying off, little or no adjustment of any kind should be required. This adjustment is called "fairing-up." When everything is nicely faired-up, the strips should be nailed in place. The distance between the strips can vary from $\frac{1}{4}$ in. to $\frac{1}{2}$ in., according to which part of the boat is being covered. The strips are fastened to the moulds with brads. Before the ribs are set up, the former must be covered with tissue paper. The object of this is to prevent the ribs and planking sticking to the former and causing great difficulty when the time comes for the boat to be removed from the moulds.

If a former is not being used, the fairing-up process must be carried out after putting the ribs into position. Any necessary packing up can be done by putting a chip or slip of paper between the ribs and the moulds. If necessary, the mould itself may be eased, but any minor adjustment can be done by rasping the rib itself off. The ribs themselves will have to have their forward or after edges, as the case may be, rubbed off, to permit the planking to

take evenly across them. The best implement to use for rubbing down the ribs is a sheet of glass-paper wrapped round a flexible slip of wood. This will rest across the ribs and ensure their being faired properly.

The ribs themselves can be made of white oak, American elm or Italian walnut. The last-named wood is not generally used for this purpose, but will be found very suitable, as it is reliable and easy to work. It is particularly good when the boat is being close ribbed over a former. The wood must be cut into suitable strips for the ribs and boiled for a couple of hours to make it pliable. The ribs can then be bent over the moulds or former, being lightly secured into position with brads or panel pins. The lower ends are fixed securely into their slots with glue and brass screws.

If the boat is not being built on a former, the size rib to use for an A-class model will be $\frac{3}{8}$ in. by $\frac{1}{2}$ in., and they should be spaced about 3-in. centres. In building on a former, the ribs can be $\frac{3}{8}$ in. by $\frac{1}{8}$ in., spaced $1\frac{1}{2}$ in. centres.

If the model is not being built on a former, the inwale (or shelf) must be put into place before the ribs are set up, and the upper ends of the ribs glued and screwed to it. The shelf will render it a matter of difficulty to remove the moulds from the boat unless due precautions are taken beforehand. It is a very good plan to make the moulds in two halves. In order to keep these together, a piece of wood can be screwed across near the top as a tie. The second tie, which is put lower down, can be nailed instead of screwed. It will be quite easy to reach the upper tie to remove the screws, and the lower tie can be levered off with a screwdriver when the moulds are taken apart to facilitate removal.

In the case of a model built on a former, it would be a matter of the very greatest difficulty to get the boat off the former if the shelf was put into position, and it should not be put in until later.

As soon as the ribs have dried out thoroughly, the boat is ready for planking-up. In a big yacht it is customary to start planking at the bottom, the garboard being the first



ANOTHER VIEW OF "YANKEE DOODLE" IN FRAME.

The completed boat is shown in the photographs facing page 114.

strake to be laid, and the sheer strake the last. In canoes and light craft, very frequently planking is started both at the top and bottom. The last plank put on is a "shutter" plank somewhere on the turn of the bilge, which fills the gap between the top and bottom planking, and completes it. Many model makers consider that it is easier to start with the sheer strake. One reason for this preference is that one will thus be working upwards instead of downwards. The main disadvantage is that when it comes to the garboard strake there will be two edges to fit at once. This can be got over to a certain extent by adjusting the rabbet a little if required.

In the present description of the methods employed, it will be assumed that the model is being built on a former and planked from the sheer strake upward. If the reader wishes to start his planking with the garboard strake, or is not using a former, he will easily be able to deduce the small alterations of method necessary as he goes along.

The planking of a model is not as difficult as might appear, and the main qualities called for are care and patience. Before starting, it must be emphasised that *on no account* must the planks be forced up at the ends, as this will cause the yacht to hog (*i.e.*, the ends to drop), immediately she is taken off the moulds. The object of the builder should be to make the planking lay naturally from end to end of the boat without forcing it edgewise at any point.

Before starting to plank, it must be considered whether the deck is to be dropped in real yacht fashion, or laid across on top of the sheer strake. Whilst it is quite satisfactory to adopt the latter plan for a bread-and-butter boat, it is not so suitable for a planked yacht. In the case of a varnished boat, the deck, if not dropped in, will show a line along the sheer strake. In any case, in a planked boat, whether painted or varnished, the builder will be well advised to drop the deck in. We have spoken of this method as being more like a real yacht than fixing the deck across the top of the sheer, but actually in a real yacht a

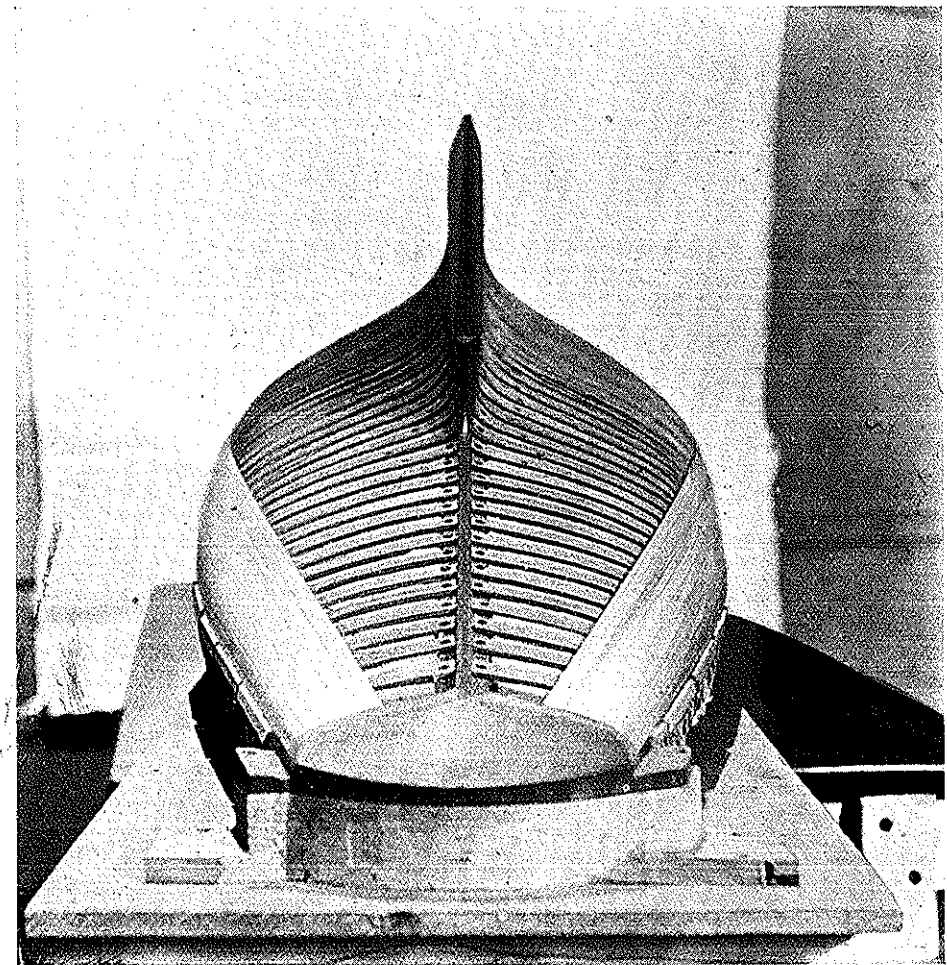
"covering board" is used. The ribs are carried up level with the top of the sheer strake. The covering board is put on top of the sheer plank, ribs and shelf right round the vessel and thus forms an edge to the deck planking proper. In a model yacht, however, it would not be feasible to fasten a covering board to the top of $\frac{1}{8}$ -inch planking, and the deck is accordingly dropped in.

When this is done, the sheer will have to be carried to the full height shown on the plan, but the ribs will have to be cut off level with the inwale, which will be lower than the top of the sheer by the thickness of the deck.

Now, in order to make the planks lay properly, they have to be cut to varying shapes and breadths, so as to cover each section proportionately. It will be found that the planks below the bilge are wider at the ends than in the middle, and those above the bilge wider in the middle than at the ends. The curvature that each plank is cut to is known as the "sny."

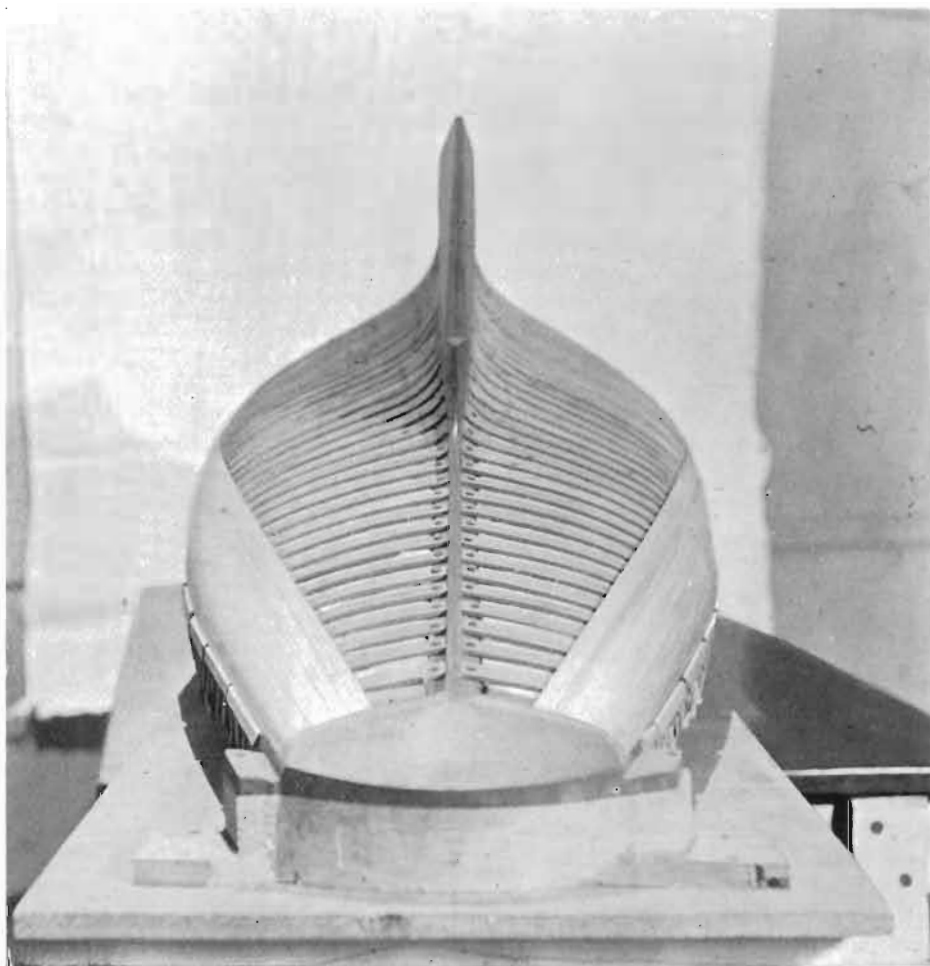
The first thing to do is to divide up the sections into widths. The diagonals on many designs give a good idea of the lay of the planking. Roughly, the planks that start at the turn of the stem should be about on the bilge on the midship section, and finish at the junction of the backbone and fashion-piece. A batten should be bent round the moulds through these points and adjusted until it makes a fair curve. The intermediate sections can be marked accordingly. This line will give the bottom edge of about the seventh or eighth plank down on an A-class model. For a boat of this class, the planks on the topsides will be about $\frac{3}{8}$ in. wide on the midship section. It is customary to make the sheer strake a trifle wider than the other planks, and not so tapered to the ends. This is entirely a matter of appearance. With a pair of dividers, set out the requisite number of planks on each section, and then transfer the markings to the other side of the model, checking the marks for the bottom plank with the batten.

Divide the distance below this plank to the garboard rabbet into three parts, and proceed

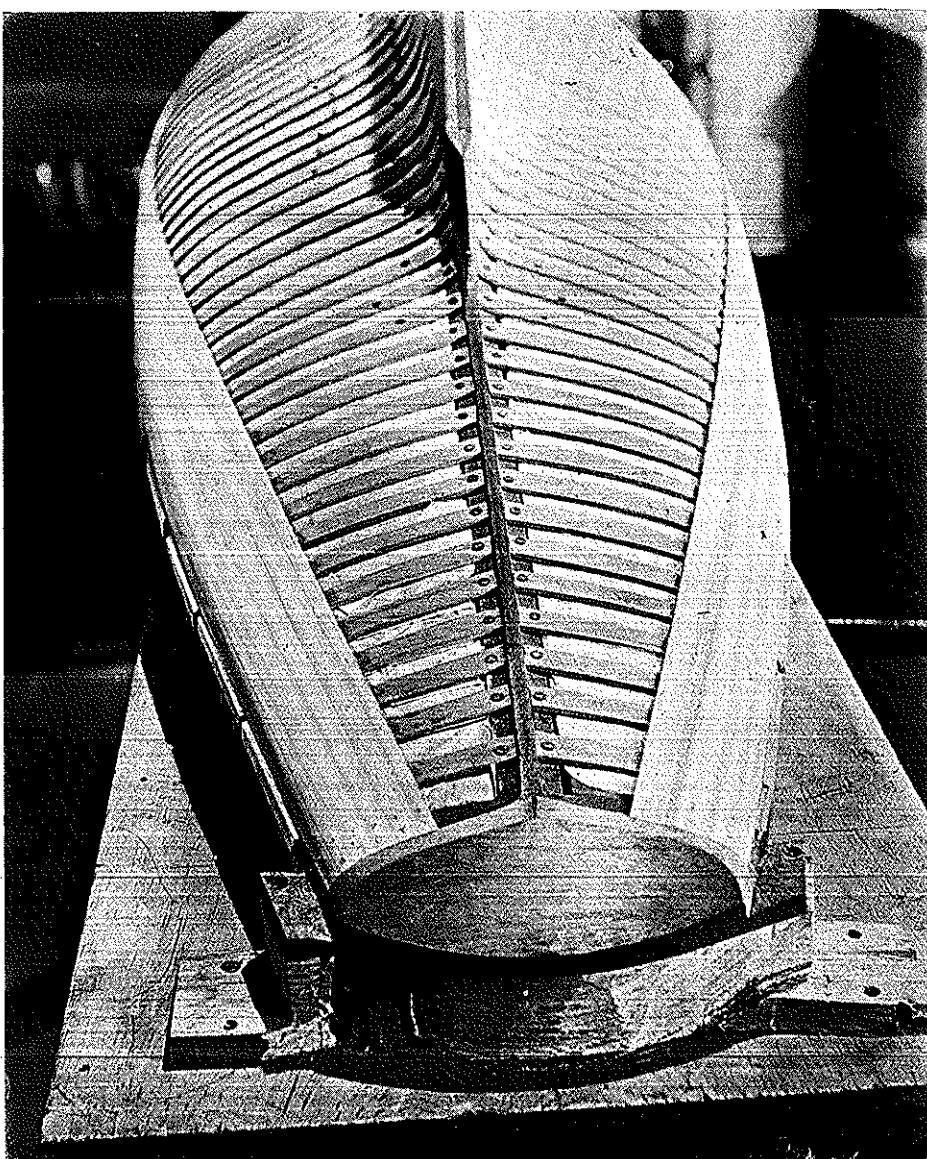


The stern view of this celebrated model during construction shows the builder's system of planking with closely spaced ribs.

"POLKA DOT" (AMERICAN B-CLASS), BUILT BY A. E. BULL.



The stern view of this celebrated model during construction shows the builder's system of planking with closely spaced ribs.



"POLKA DOT" PARTIALLY PLANKED UP.

Note the tissue paper between the ribs and the former.

[To face page 113.]

PLANKING A HULL

to set out the rest of the planking in groups. It will be seen that the planks change gradually, and, as mentioned above, the garboards are wider at the ends than at the middle.

The experienced builder will not require to divide his sections up in this manner, but the novice will find it a great assistance.

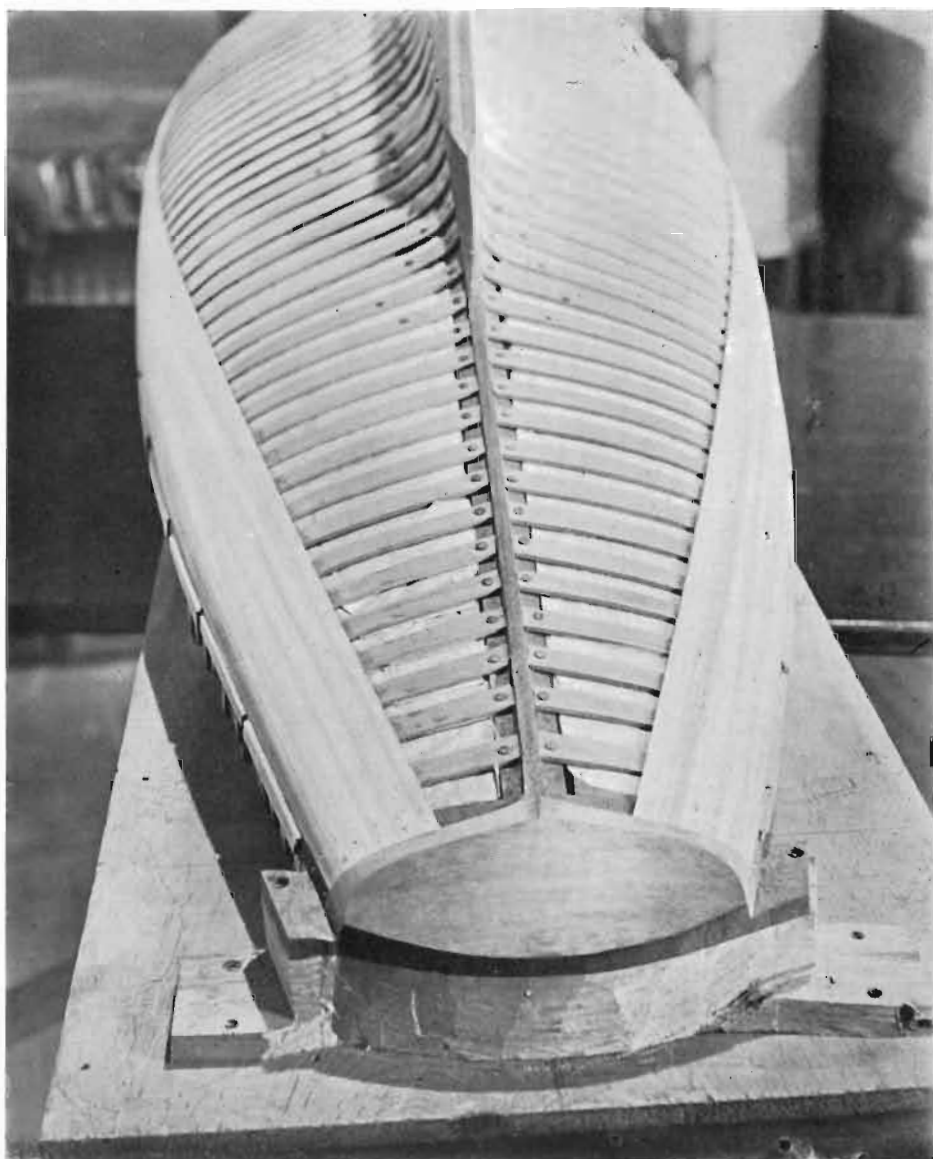
There are several methods of arriving at the correct shape of the planks, but the easiest is to use a "spilling plank" (or "trying plank"). A piece of wood similar to what is being used for planking up is cut about 3 in. wide and a suitable length. This is offered to the boat. It will be found that when the centre is in position on the midships section the ends are away, so that the correct plank will have to be concave. Tack the trying plank into position, arranging matters so that the gap at each end is alike. Mark on the plank the position of each section. Take a pair of dividers, and setting them about $\frac{1}{4}$ in. wider than the gap, prick off on each section. A line drawn through the spots so found would give the correct shape of the top edge of the sheer. The trying plank is now removed from the moulds, and the spots obtained are set out on the actual wood from which the sheer plank is being cut. A line is drawn through the spots, using a batten and a sharp pencil, and the board is cut just outside it. To obtain the lower edge of the sheer plank, measure on each section with the dividers to the spots set out for the edge of the next plank. The line is again put in with the batten, and the plank cut outside and trimmed dead sharp on the lower edge. From the strake so obtained, the corresponding plank for the other side of the boat is marked out. When the pair are made they can be fitted. In fitting, glue the plank to the ribs and fasten at the ends with $\frac{1}{4}$ -in. No. 6 brass screws. For fastenings to the ribs, some builders use these brass screws also, but brass or copper pins are better and less expensive. The best are copper pins. There is sometimes difficulty in getting these little copper pins, but Chamberlain's, Waterloo Bridge Road, London, stock $\frac{3}{8}$ -in. No. 20, which are eminently suitable for the purpose.

The reason for always putting the planks on in pairs is to avoid forcing the moulds out of position. In putting the pins into each strake they should be staggered, the upper pin in the plank being slightly forward of the centre of the rib and the lower pin aft of it. By this method the pins do not both go through the same grain of the wood in the rib, and a stronger job is made without fear of splitting. The pins should only be driven half in as yet. The reason for this will be explained in due course.

The second pair of planks has now to be fitted. The trying plank is again offered to the hull, preferably on the opposite side to the first time. The shape for the fitting edge is again spotted for with the dividers, and laid off on the planking wood. The other edge is marked out in a similar manner to the second edge of the first plank. When the pair of planks has been cut just outside the lines, it is offered to the boat and fitted to the first plank. The planks should fit as closely as possible and it should not be necessary to force their edges together. When the planks are fitted, the second pair can be put into position, being glued edge-to-edge with the first planks and to each rib, and at the ends. They are fastened in the same manner as the first planks, and the pins are not driven home. It must be apparent to the builder that the cleaner the second edge of each plank is left, the easier it will be to fit the subsequent plank to it.

The planking process is continued in this manner until the first group of planks is complete. The space for the second group is then checked, and if necessary adjusted, and then this group of planks is put on in a similar manner. During planking up, care should always be taken to keep the planking at the same height on each side.

As soon as the planking is completed and the glue has set hard, the boat can be glass-papered down. If this is done before she is taken off the former, there will be less chance of straining her during the process. Before glass-papering, remove all the pins. As the hull is glued together, it will remain firm during the operation of rubbing down. In



"POLKA DOT" PARTIALLY PLANKED UP.

Note the tissue paper between the ribs and the former.

MODEL SAILING CRAFT

building a hull direct onto the ribs without a former, the pins can be driven home before rubbing down, but this has two disadvantages. As the pins are long enough to go through and be turned down, they naturally are long enough to penetrate the moulds and cause difficulty in removing them from the boat. The other disadvantage is that during the process of rubbing down the pins lose most of their heads, and their holding strength is impaired accordingly.

The rubbing-down process is very important. As mentioned in a previous chapter, this should be done first across the grain of the wood, the planking being traversed in the direction of the cross sections. The glass-paper should be wrapped round a suitable piece of thin flexible wood. Coarse grade is used for the start, and gradually finer is used till the final rubbing down is done with the finest grade. It will take some hours' work to fair up an A-class boat properly. By this time all the plank edges will have been rubbed right down, and the hull be perfectly faired up. Always look at the hull from different angles, and occasionally from a little distance, during the fairing process, and persevere until the hull is absolutely perfect. The final rubbing down with fine glass-paper must be done in the direction of the planking.

The hull can now be removed from the former, and the shelves (or inwales) fitted. The shelf is a very important part of the structure of a yacht, and it is a mistake to make these too light. For an A-class model a suitable size would be $\frac{1}{2}$ in. wide by $\frac{3}{4}$ in. deep. The greatest strength is needed at the shrouds and in the middle of the boat, and these could with advantage be tapered down to $\frac{1}{2}$ in. deep at the bow, and $\frac{3}{8}$ in. at the stern. Suitable slots are cut in the stem and fashion-piece to house the ends, and the shelves sprung into position. The height of the shelves is governed by whether the deck is being dropped in or not. The best material for the shelves is pine or cedar.

Before finally fitting the shelves, check the beam of the boat and, if necessary, adjust this before inserting them.

It will be seen that when the shelves are in position, there is a gap between the shelves and the sides between the ribs. Packing pieces have to be fitted into these. These are made from slips of pine, and are arranged the same height as the top of the shelves. The packing pieces are fixed into position with glue and pinned through from the outside. It would be possible to use a thicker shelf and notch it for the ribs, but were this done, a series of bends and flats would result, instead of a true curve.

The beam of the yacht should again be carefully checked to make sure that she has not sprung, and two or three temporary ties put across her until such time as the deck beams are made and fitted.

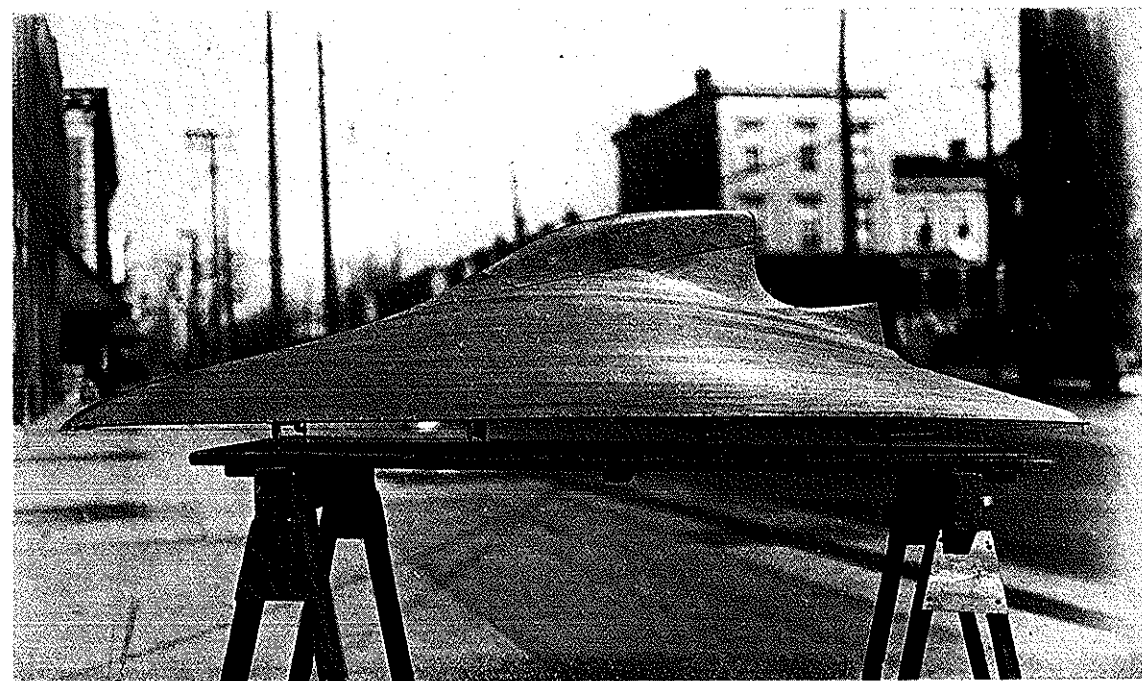
The pins are now replaced and driven home, using a light hammer and a pin punch. The ends are turned over inside the boat. The best method is to turn these downwards and punch the point in flush with the grain of the rib.

In an A-class, or other big boat, especially when a detachable keel is fitted, it is advisable to fit two floors across the boat from bilge to bilge in the way of the main keel-bolts. These are best of mahogany, and can be cut from $\frac{3}{4}$ -in. wood. Their depth should be about $\frac{3}{4}$ in. where they cross the keelson.

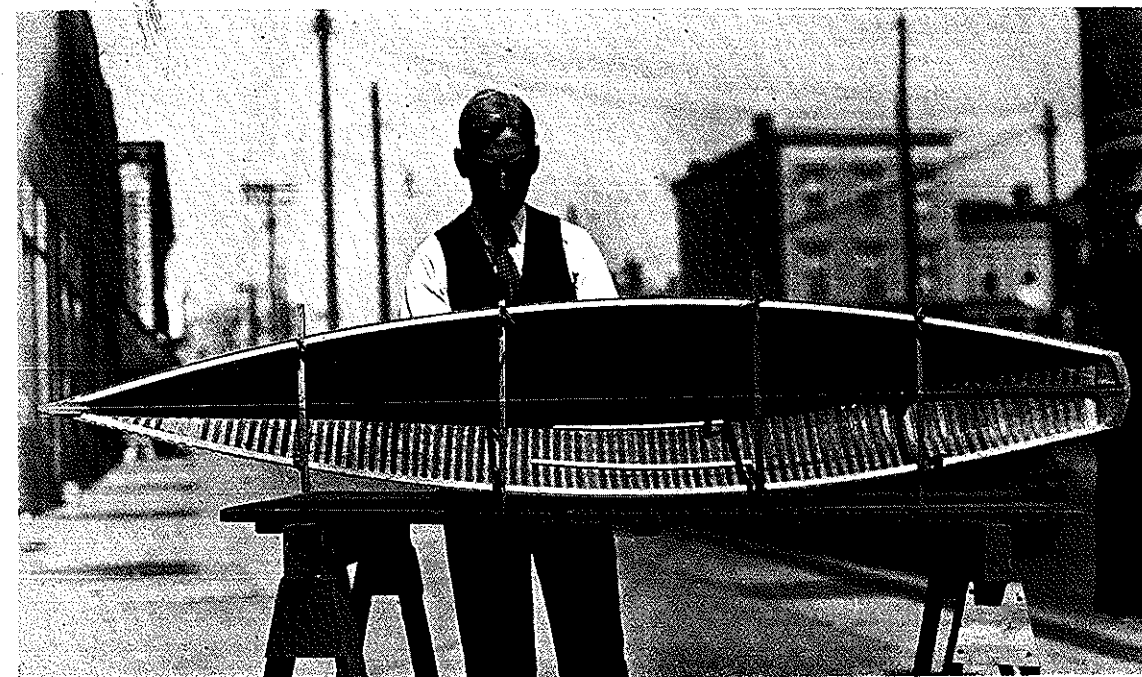
The fitting of the keel, braces for the shroud plates, rudder-tube, mast-step, etc., are explained elsewhere in this book.

If the boat is of the fin-and-skeg type, the skeg should have been fitted when the backbone was assembled. If the keel is fixed, this could also have been bolted to the backbone before setting up, though many builders do not do so for the sake of convenience. In any case it should have been made and carefully tested for alignment with the backbone before the boat was set up for building.

It has been mentioned that when a boat is built on ribs spaced at the sections, it is often desirable to fit extra ribs in between the main ribs. There is no difficulty about bending these additional ribs into the hull after removal from the moulds, but the slots in the keelson and backbone to receive the ends will have



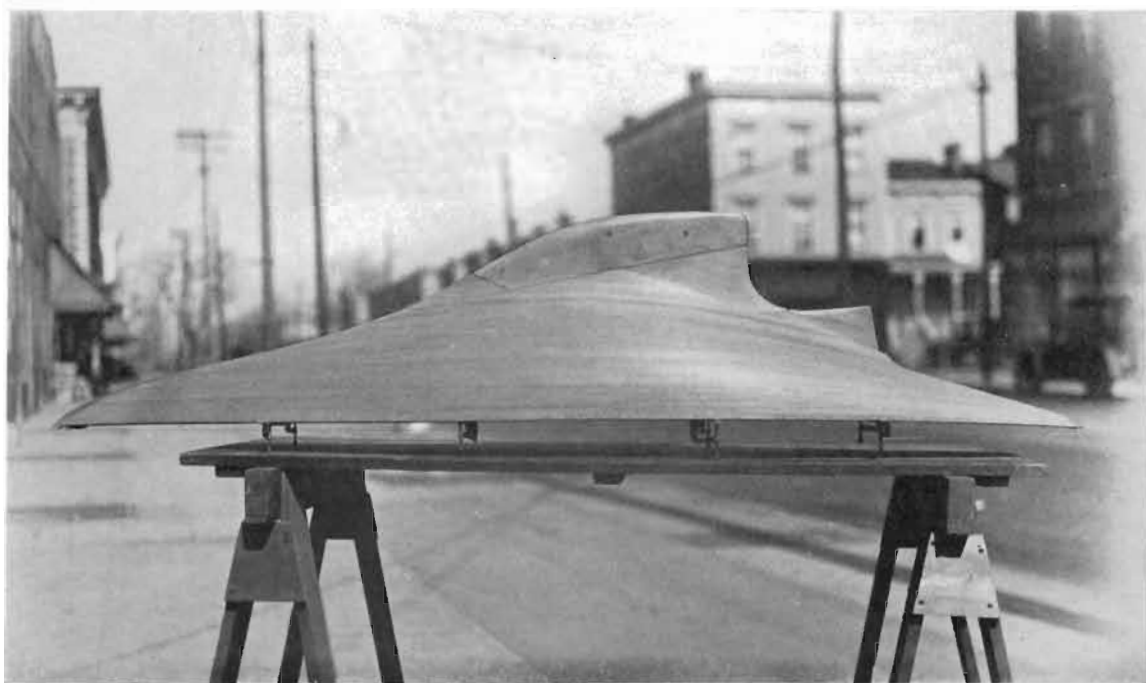
THE COMPLETED HULL.



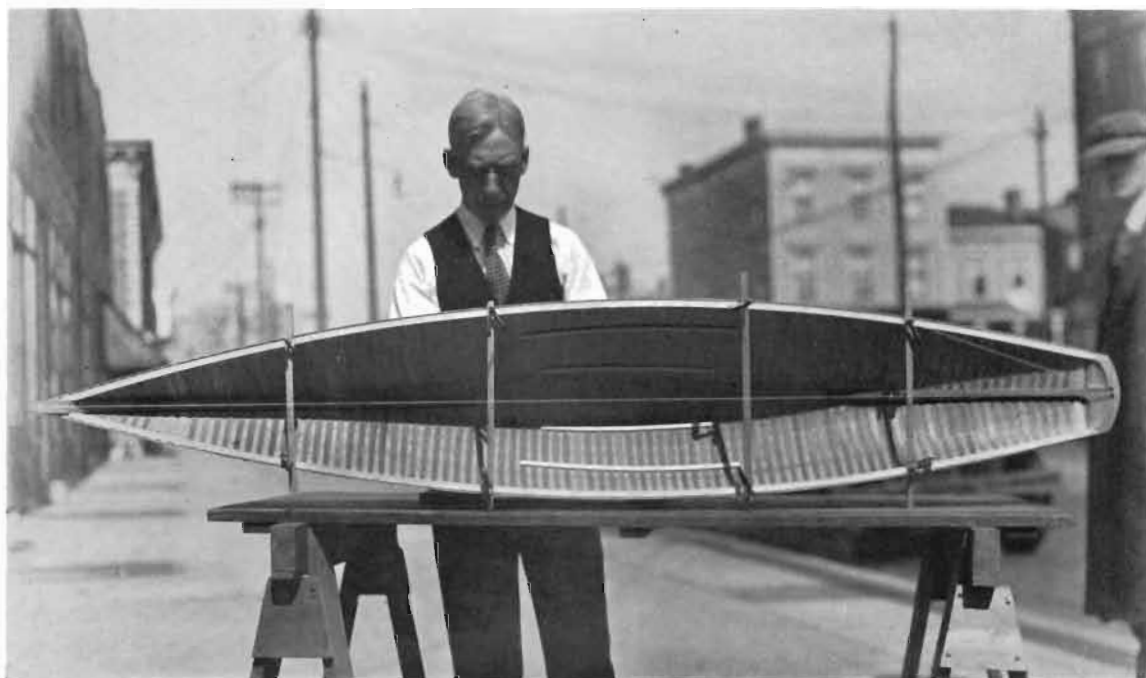
THE BUILDER, A. E. BULL, AND "YANKEE DOODLE."

Note the short stringers in the way of the lead keel.

[To face page 114.]



THE COMPLETED HULL.

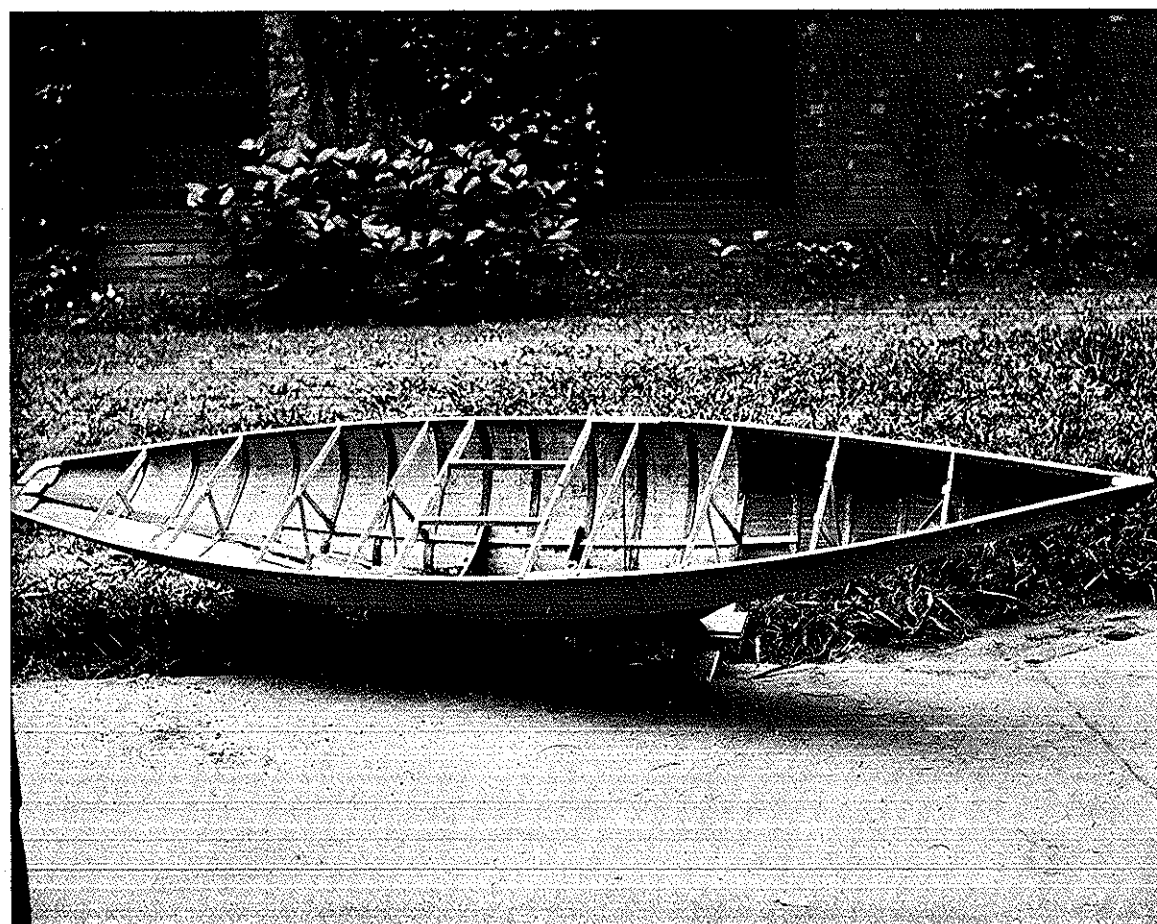


THE BUILDER, A. E. BULL, AND "YANKEE DOODLE."

Note the short stringers in the way of the lead keel.

[To face page 114.]

A NICE EXAMPLE OF THE ORDINARY METHOD OF BUILDING A PLANKED MODEL.



"CLAIRE" (BUILT BY FRANK HUMPHREYS, U.S.A.).

The design for this A-class model was developed from the lines of an 18-ftr. by J. W. Daniels.

[To face page 115.]

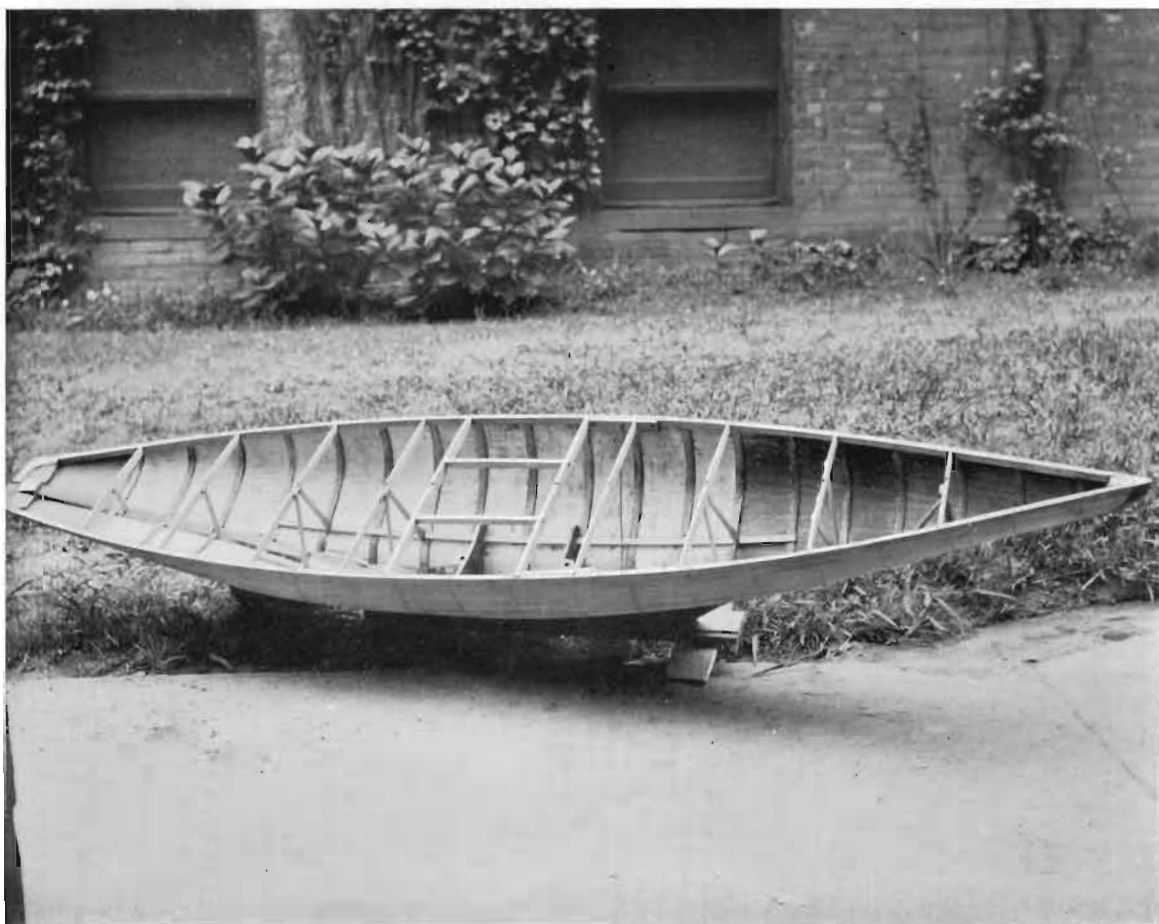
VARNISHING THE INSIDE

to be cut before planking is started. The ribs must also be put into position before the packing pieces are fitted along the shelves.

The hull is given three good coats of varnish inside. The first of these should be half

varnish and half turpentine, to sink well into the wood. Should there be any places where the light shines through the seams, care should be taken to rub the varnish well into these to act as caulking.

A NICE EXAMPLE OF THE ORDINARY METHOD OF BUILDING A PLANKED MODEL.



"CLAIRE" (BUILT BY FRANK HUMPHREYS, U.S.A.).

The design for this A-class model was developed from the lines of an 18-ftr. by J. W. Daniels.

CHAPTER XIII

Lead Keels. Making Plaster Moulds for Casting. Sand Moulds. Casting a Keel. Finishing up a Casting. Drilling Lead.

THE casting of a lead keel is a task which the builder may well be excused for not attempting, as it is by no means an easy matter, especially with the resources that the amateur is likely to have at his command. Moreover, the cost of getting a casting made at a foundry is very little more than what must be paid for the actual metal.

If, however, the amateur builder has not a foundry near, or wishes to do everything for himself, there are two methods that can be used, as the mould can be made of plaster or sand. Probably the amateur will find it easier to cast in a plaster mould, but both methods are given here, and the builder can take his choice.

Whether the keel is to be cast at a foundry or at home, the first essential is a good pattern. Every little irregularity of surface in the pattern will be multiplied in the casting, and it is, therefore, imperative to rub the pattern down until it is absolutely smooth. Some moulders also recommend that the pattern should be varnished and rubbed down again afterwards.

For making a plaster of Paris mould, the ordinary plaster, as used by plasterers, is not to be recommended, as it is too coarse to get the best results. Ash's Dental Plaster will be found excellent. The quantity required to make a keel of about 40 lb. for an A-class model will be roughly 22 lb.

In order to make the first half of the mould, a shallow, lidless box is required. This should be about 3 in. deep and about 2 in. larger than the pattern all round. A stout cardboard box will answer the purpose, or a rough wooden box can be knocked up.

The wooden pattern must be well greased all over in preparation for making the mould. Vaseline is best for this purpose. The plaster for the first half of the mould can now be mixed. This can be done in an enamelled bowl about

15 in. diameter. The bowl is filled about two-thirds full of clean cold water and plaster is poured into the centre of the bowl until it shows above water. A large clean iron spoon is taken and the plaster is stirred until all the lumps have disappeared. It should then be of the consistency of thick cream and be gradually thickening. Pour the mixture into the box until it is full. The wooden pattern is now pressed firmly into the centre of the plaster until it is half submerged. The plaster will have become very thick by this time, so with an old knife smooth the top surface over. It is not necessary to get this mathematically level, but there should be no lips on the surface, otherwise the other half of the pattern will not part from it easily. Any airholes showing on the surface should be filled in with plaster.

In a short while the plaster will be set and can be further trimmed up, and any loose plaster should be wiped off. Before the plaster gets too hard, a pyramid-shaped hole should be made in each corner about 2 in. from the outer edge. These holes can be about $\frac{1}{2}$ in. across. The object of them is to act as keys to keep the two halves of the mould in their respective positions during casting.

The bowl must be cleaned out before mixing the plaster for the second half of the mould. As soon as the balance left in the bowl has set hard, the bowl should be placed under running water and knocked with the spoon. The plaster will then come off in lumps.

Before making the second half, the first half must be given a coat of clay wash. A brush is dipped in water and then rubbed in soft clay and liberally applied to the surface.

The plaster for the second half-mould is mixed in a similar manner, but this time a layer must be poured over the top surface of the first half and the pattern whilst the plaster is still quite thin. As the plaster thickens, the re-

MOULDS FOR CASTING LEAD KEELS

mainder is gradually applied until the pattern is covered with a layer at least an inch thick. The second half can now be worked up and trimmed off.

The whole thing should now be set aside and allowed to set properly hard. If the plaster has been mixed correctly, this will take half an hour or so.

The mould can now be removed from the container, and the edges trimmed up with the old knife until the joint between the two halves shows as a hair-line. To part the joint, put the mould edgewise under a slowly-running tap and slightly assist the parting with a thin knife. The two halves should now come apart without any difficulty, and the pattern can be removed.

If the cores for the bolts have been left in place in the pattern and care taken that the first half-mould comes exactly halfway up these, it will save a lot of trouble. The pieces of spoke left over from making the keel-bolts will serve admirably as cores. If this has not been done, small grooves must be cut in the correct places and the cores set into position with clay.

The pouring-hole and vents must now be cut. The pouring-hole should be at the highest part of the keel, and small holes should be provided at either side as air vents. If the keel has a thin end, a small vent about an inch long should be cut at this point to allow all air to escape.

When complete, the mould should be well blacklead all over the surfaces and the two halves tightly bound together with stout cord or wire. It should then be set aside to dry for about a fortnight before being used.

* * * *

The alternative method of making a sand mould is considerably cheaper, as all that is required is some moulding sand and a little parting sand. Moulding sand is rather of a loamy nature, whilst the parting sand is fine and sharp.

In order to make the lower part of the mould, a wooden box is required. This should be about 2 in. larger than the pattern all round.

This box has a bottom but no lid, and the depth should be about three times that of the pattern.

For the top half of the mould a framework is needed. This is exactly the same size as the box for the lower part, but has neither bottom nor lid. Four pieces of wood are nailed on to the sides of the frame for the upper part, in such fashion that they project over the lower part and keep the top portion from sliding about.

To make the sand mould, the sand is damped and put into the box little by little, and rammed down as it is put in, until it is absolutely firm.

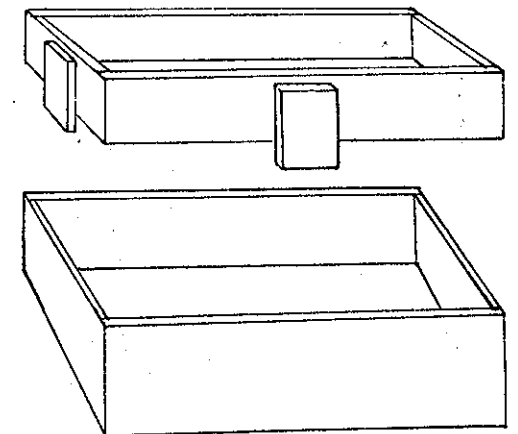


FIG. 55.—THE MOULDING BOX.

When about $\frac{1}{4}$ in. from the top the box is filled right up and the pattern inserted. Push it in until it is half covered, and lies flat with the other half sticking up. Ram down the surrounding sand very firmly and level off to the edge of the box. Parting sand must now be sprinkled over the surface of the sand mould.

The upper frame is now fitted on to the box. Continue filling up with sand little by little, ramming it down firmly all the time. Any suitable tool (such as the end of a mallet head) can be used as a rammer.

In the moulding shop of a brass foundry the bench is low, being about 2 ft. from the ground at most. From the roof ropes depend. Taking the rope in his hands, the moulder mounts the bench and with his feet rams the

MODEL SAILING CRAFT

last part of the sand down, using all his weight. There is a knack in doing this, and it has been described as the moulder's "War-dance."

It is not to be expected that the amateur will do this, but it is mentioned to show how important it is to get the sand properly rammed home.

In making the mould for casting a large yacht's keel, such as an "America's" Cup challenger or defender, hot irons are used in ramming down the sand.

When the top part is full and tight, it can be carefully lifted off, when the sand it contains will come with the frame. The wood pattern has now to be removed from the mould

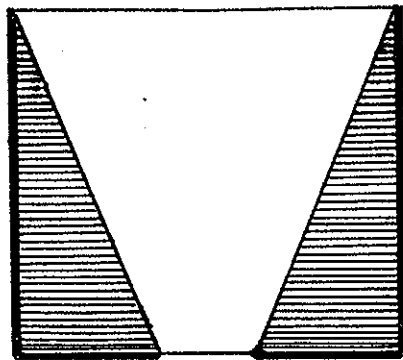


FIG. 56.—THE SAND FUNNEL.

without disturbing the sand. This can be done by using two gimlets, which are screwed into the pattern. The impressions left in the two halves of the mould can be smoothed with an old spoon or similar implement.

A hole must now be drilled straight through the sand in the upper half of the mould at the deepest part of the impression left by the keel pattern. This hole should be about 1 in. in diameter. Two rather smaller holes must also be made to act as air vents. These second holes are also made in the upper half-mould, and should be at the shallowest part of the impression.

The two halves of the mould must now be baked thoroughly dry and hard. The upper half is now replaced in position on top of the lower part, and the two clamped firmly to-

gether, in order to prevent the mould lifting when the lead is poured in.

In order to pour the lead into the mould, a funnel made of sand is necessary. A small, round tin is obtained, and a hole is made in the bottom the same size as the pouring-hole in the mould. The tin is then tightly packed inside with sand with a funnel-shaped hole through it. The funnel is also baked hard, and set in position over the hole in the mould. Everything is now ready to cast the keel.

* * * *

For melting the lead, a Primus stove or furnace will be found useful, but the builder will have to use whatever is available in this respect. The lead can be melted in an old iron saucepan, or similar strong receptacle. The pot should be absolutely clean, and a big old spoon or ladle is required for skimming and removing dross.

One and a half times the amount of lead required for the keel should be provided as a minimum. If the keel is a large one it is advisable to melt this in two or three small pans instead of one big one, because it will not only avoid cooling, but be easier to pour. As the keel must be cast in one attempt, it is essential to have an ample amount of lead ready.

Thoroughly melt the lead and skim off all dirt, dross and foreign matter. The lead should be poured in as fast as possible, so that the first part will not have cooled off by the time the rest arrives. After a little while lead will appear at the hole in the small end of the mould. Continue to pour, as the lead will contract as it cools, and more is needed. Fill the mould right up to the top of the funnel and if necessary keep the pouring hole clear with a stick. Set aside to cool.

The keel should be cool enough to handle in about an hour. Separate the two halves of the mould and remove the casting. As the lead contracts as it cools off, it is a good plan to remove the cores (which have been cast in for the bolt-holes) before the lead is cold.

It might be mentioned that it will facilitate the withdrawal of the cores for the bolt-holes if the cores are lightly greased before

FINISHING A KEEL CASTING

being put in position in the mould. A good way of doing this is to smoke them in a candle flame.

A caution should be given not to do the casting on a cold stone floor, or to let the molten lead come near anything damp or cold, as it will "shoot." Splashes of molten lead are nasty, and for one who is not used to handling it, it is not a bad plan to protect the hands with an old pair of gloves. Great care should also be taken to keep the face and eyes away from the danger of splashes.

It is desirable to have the keel-bolt cores slightly full, as this will ensure their being easily withdrawable. Also the keel pattern should be a little full, as it allows for trimming up, and it is far easier to take a little off than to add weight.

In cleaning up a keel casting, various tools can be used. Ordinary files soon clog up and become useless, but a Dreadnought file can be relied on. A small iron plane is also useful, and a plumber's shavelock cuts lead down rapidly. If it is necessary to shoot the top of the lead keel, this can be done with an iron jackplane. The edge should not be quite as fine as that required for hardwoods. The plane sole and lead should be liberally lubricated with turpentine, and the plane iron should be set to take a fine shaving. In shooting the top of a keel, care must be taken to get this absolutely true in a thwartships direction, as if it is the least bit out, the keel will be out

of truth and the yacht will behave differently on the two tacks.

A blowhole in the casting can be stopped with solder if required; but if the keel is to be painted, a stopping can be made of equal parts of red and white lead, with a little gold size to bind it. This stopping can be used, if necessary, to build up a slight flat on a casting. It sets quickly, and should only be made up as wanted.

If it is necessary to drill holes in lead, this can be done with an ordinary twist bit. The bit should be kept freely lubricated, turpentine again being used, and lifted and cleared frequently, to avoid binding.

If the balance of the lead keel is out, or it is desired to slightly reduce the weight, whilst at the same time not altering the lead-line by planing lead from the casting, this can be done by drilling holes downwards from the top face.

If the fore edge of the keel is to be fitted with a brass band or the bottom with a brass shoe, the best method of attachment is with small brass screws. A hole is drilled just a size too small to clear the screw. An iron screw is then passed into the hole, and cuts the thread as it is screwed home. The iron screw is then withdrawn and a brass screw of exactly the same size substituted. The reason for using the iron screw first is that the brass screws are apt to twist off and break inside the lead.

CHAPTER XIV

Rudders and Fittings. Deck-beams. Decks. Covering Boards. Hatches.

WITH the sole exception of the old-fashioned and inefficient weighted rudder, all steering gears function above deck. The rudder is composed of two parts—the flat part, known as the “blade,” and the stem, which is called the “rudder-post.” The top of the rudder-post is known as the “rudder-head.”

In order to accommodate the steering gear, it is, therefore, essential to carry the rudder-head above the deck. In the case of a square-sterned yacht, with the rudder hung on the transom, the rudder-post passes outside the boat, but in the ordinary counter-sterned vessel it will be necessary to fit a “rudder-tube” to accommodate the rudder-post.

In order that the rudder may be a snug fit, it is customary to make a groove down the after end of the keel or skeg. This groove is hollowed out with a small rat-tail file, and is faced with brass, the facing being formed from the continuation of the rudder-tube.

For the rudder-tube of an A-class model, a piece of $\frac{1}{8}$ -inch light-gauge brass tube will be suitable. The length must be sufficient to reach from the pintle to a point about $\frac{1}{4}$ in. above the centre of the deck. The actual rudder-tube is, of course, composed of the part that actually passes through the hull. Below the hull, the tube will be cut away until only a strip the exact width of the after edge of the keel or skeg is left. The usual width at this point will be found to be about $\frac{1}{4}$ in.

The size of the rudder-post will vary with the size of the boat, but it is best to err on the side of strength at this point. Many a race has been lost by reason of the rudder-post twisting, and the size of the rudder-tube is governed by the size of the rudder-post.

When purchasing the tube for the rudder-tube, a piece of brass tube for the rudder-post should also be obtained. The rudder-post must be a very easy fit in the rudder-tube, and show no sign of binding.

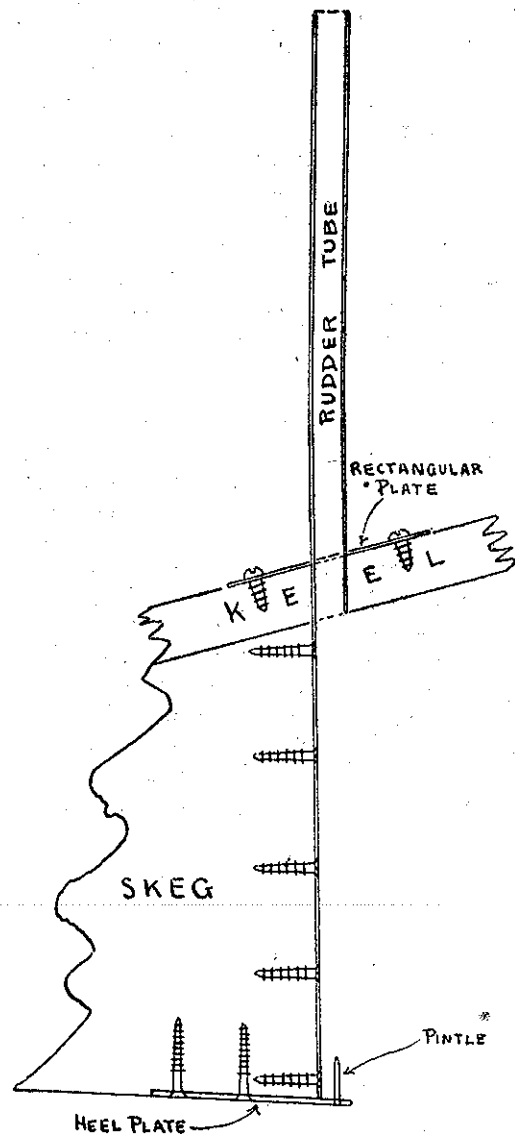


FIG. 57.—THE RUDDER-TUBE AND PINTLE AS FITTED TO A BOAT WITH FIN-AND-SKEG TYPE OF KEEL.

The lower part of the rudder-tube can be cut away with a hacksaw and finished up with a file. It is by no means easy to file this strip

FITTING THE RUDDER TUBE

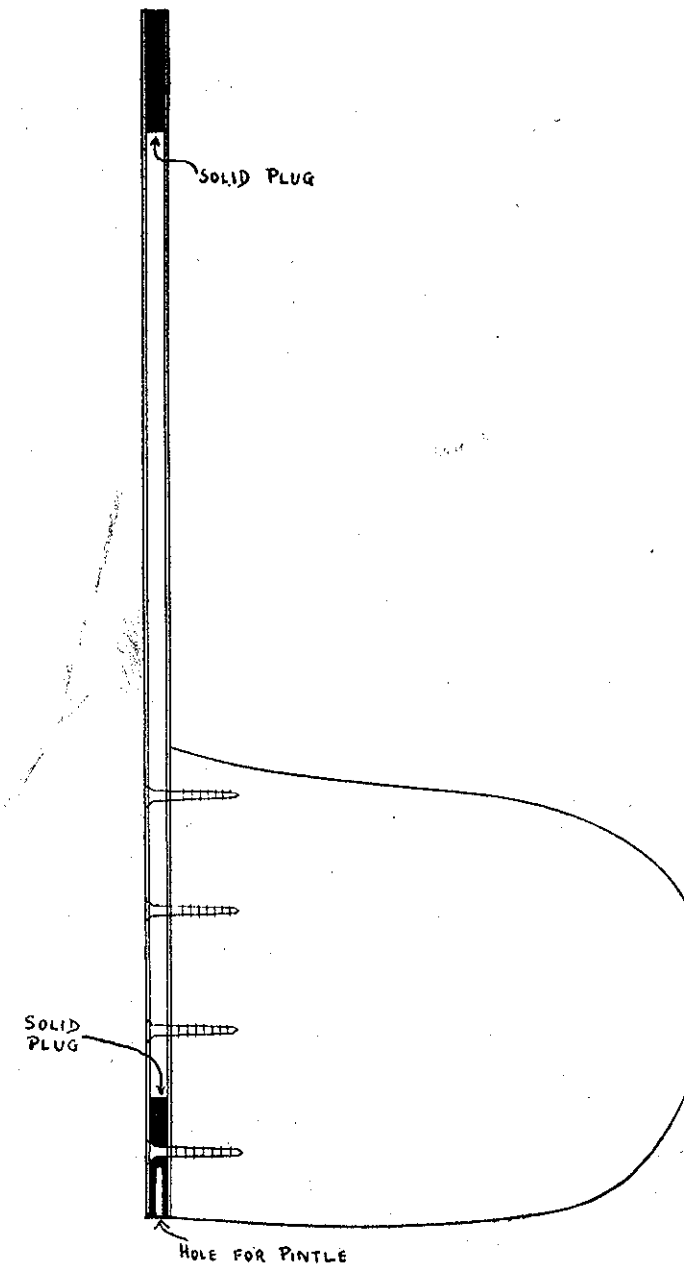


FIG. 58.—METHOD OF MAKING RUDDER.

down without breaking or bending it. A piece of rough wood is taken and set in the vice. The wood should be as long as the

rudder-tube. A groove is cut in it to accommodate the tube. This will make it quite easy to hold the tube whilst filing down and drilling the necessary holes for the screws to hold it to the stern-post. “Stern-post” is the name given to the after edge of the keel or skeg which carries the rudder.

Starting at the bottom of the strip, about $\frac{3}{8}$ in. from the end, drill holes every inch and countersink them. The holes should be large enough to clear a No. 1 brass screw. The greatest care must be taken not to bend the rudder-tube or rudder-post. A hole must now be drilled in the hull to accommodate the rudder-tube. This must be at the exact angle, and fall so that it covers the groove in the stern-post.

The rudder-tube must now be temporarily put into place, and the top screw should be inserted to keep it in position. The rudder-post can now be tried to see that all is aligned right, and that it is a good fit.

A rectangular plate must now be cut from thin sheet brass. An oval hole is cut in this so that it passes over the rudder-tube and lies flat on the keelson. Four screw holes are made in this to clear a No. 1 screw. The plate is soldered to the rudder-tube, and, in order to get this at exactly the correct angle, the soldering should be done in position in the boat. The rudder-tube, complete with plate, is now removed and properly fitted, the wood behind the brass being luted with white-lead paint.

The rudder itself can now be made. The first procedure is to see that the rudder-post is an easy fit in the tube. If not, it must be eased down with emery cloth.

A brass plug must be sweated into the lower end of the tube which is to form the rudder-post. To do this, clean the inside of the tube well, also clean and tin the plug. Put some flux into the tube, insert the plug, and heat until the solder runs. A hole $\frac{1}{4}$ in. deep should now be drilled into the plug from the bottom to take the pintle on which the rudder hangs.

The rudder-post should next be cut to length, allowing sufficient to project an inch above the deck. A plug about an inch long has then to be sweated into the upper end.

The wooden blade of the rudder must be cut out next. Mahogany is best for this purpose. A groove must be cut down the forward edge of the blade to accommodate the rudder-post. A rat-tail file can be used to do this. Holes an inch apart are drilled through the rudder-post and countersunk for the screws holding the post and blade together. These should be $\frac{3}{4}$ -in. No. 1 brass screws. The lowest screw should come immediately above the plug in the bottom of the rudder-post. The blade is fixed to the post with white-lead paint as bedding. Except for fitting the steering gear, the rudder is now complete. The construction of the rudder is shown in Fig. 58.

The only other rudder fitting required is the pintle which supports the heel. This consists of a strong strip of brass the same width as the skeg. This has two holes for the screws that fix it to the skeg, and a pin for the rudder to pivot on. The pin (or "rudder pintle") is just a trifle longer than the depth of the hole in the bottom of the rudder-post. This ensures the rudder resting on the pintle, and not on the strip of metal (see Fig. 57).

In full-keel boats the bottom of the lead keel sometimes comes below the rudder heel (see Fig. 59). In this case a saw-cut must be made into the lead to take the brass strip. This strip is then grooved to prevent it moving

sideways, and driven into the saw cut and soldered over.

* * * *

The deck-beams are a very important part of a vessel, as they form transverse ties to the upper part of the structure. Their construction and fitting is consequently a matter of great importance.

The deck of a yacht is cambered, and, consequently, the deck-beams are arched. However, their under side cannot be hollowed, but must be straight from side to side. If they were

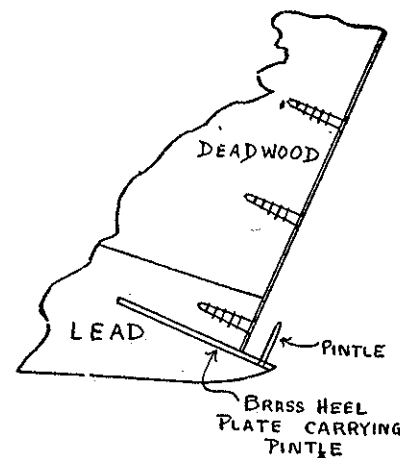


FIG. 59.—METHOD OF FITTING RUDDER PINTLE IN A FULL-KEEL MODEL WHERE LEAD EXTENDS TO HEEL OF STERN-POST.

hollowed, the beams would soon flatten out and the sides of the yacht be pushed apart. For the beams of an A-class boat the scantling can be $\frac{1}{4}$ in. wide by $\frac{1}{4}$ in. deep at the ends. The depth of the beam in the middle will be $\frac{1}{4}$ in. plus the amount of rise of deck at that particular point.

In cutting out the deck-beams, it will not be correct to use a fixed radius and depend on the lesser breadth of deck reducing the height as required at the various stations. The height must be taken from the drawing at each point and the beams marked accordingly.

As in the case of ribs, it is better to have a greater number of deck-beams of light scantling rather than a lesser number of heavy scantling. The beams can be made of pine.

In fitting deck-beams, allowance must be made if the deck is to be dropped in. Otherwise they will be set level with the gunwale. The best way to fit the deck-beams is to mortise them in, as shown in Fig. 60. This method keys the beams in place. The ends of the beams should be glued and screwed into position.

The spacing of deck-beams is a matter for some consideration. It should be arranged that one beam comes at the rudder-tube. Beams should also come fore and aft of the mast-hole. Some builders also fit mast-partners. These are fore-and-aft beams between the deck-beams on each side of the mast-

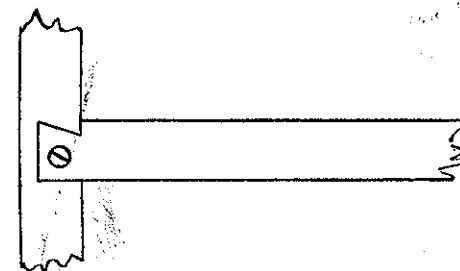


FIG. 60.—METHOD OF MORTISING END OF DECK-BEAM INTO SHELF.

hole. Beams should also come exactly under the coamings of the hatchway. Here again some builders fit "carlines" (longitudinal deck-beams). Mast-partners and hatch carlines are really unnecessary, particularly in smaller sizes of boats. Whether these are fitted or not is a point on which every builder must please himself. It is a good thing to arrange that beams come under the main deck fittings, such as the two horses, the ends of the jib-rack, steering-gear pulleys, etc. The deck-beams on an A-class boat should not be more than about 6 in. apart if they are the scantling mentioned above, and of pine. Heavier beams of mahogany might be as far apart as 9 in.

When the beams have been fitted and varnished, the deck can be made and fitted. Pine is the best material for this. Holly is a very white wood, but is inclined to buckle when exposed to damp. If there is any difficulty in

getting a piece of wood wide enough for the deck, two pieces can be joined together down the middle. The deck of an A-class boat can be $\frac{3}{8}$ -in. pine, or even a trifle lighter, if plenty of deck-beams are fitted. The method of joining two pieces of wood to form a deck is as follows: the edges to be joined must be shot absolutely straight. Then put newspaper down on a board to prevent sticking, and glue both edges with casein glue. Panel pins can be driven through the outer portions that will be cut off when the deck is shaped up. Along the centre seam weights must be put to keep the edges firmly together. Paper should be put under the weights to prevent them sticking to the wood. If this is carefully done, an excellent joint should result. When the glue is set, the deck will have to be planed down. The plane must be very sharp and set fine. The deck is afterwards glass-papered well until a good finish is obtained. On the upper side, mark out the hatch opening, the mast-hole and the hole for the rudder-tube. On the underside at these points glue suitable pieces of material. Cuttings of sailcloth are admirable for this purpose. This will prevent splitting. Draw a centreline along the underside of deck in pencil, if in one piece.

Another excellent material for decks is the 1 mm. waterproof three-ply used in aeroplane work.

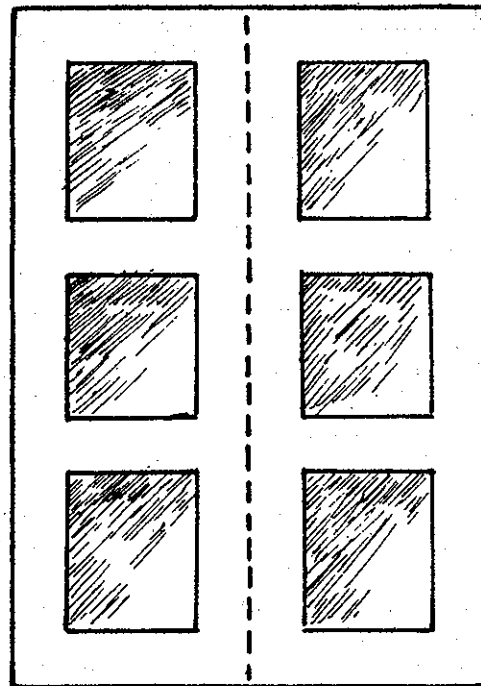
The deck can now be offered to the boat. Get it exactly into position and mark out the shape with a sharp pencil. If the deck is not being dropped in, it can now be cut out about $\frac{1}{8}$ in. outside the line. If the deck is being dropped in, it can be cut exactly on the line and eased until it drops into place. In the case of a let-in deck, if the chamber in the fashion-piece and rebate in the top of the stemhead to receive the deck have not been cut, this must now be attended to.

Owing to the lightness of the deck, screws will not hold properly in it, and it is necessary to glue reinforcement pieces on the underside wherever a fitting comes unless there is a deck-beam at this point. The reinforcement pieces can be slips of $\frac{1}{8}$ -in. mahogany or $\frac{3}{8}$ -in. pine.

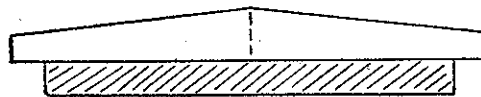
The opening for the hatch has now to be

MODEL SAILING CRAFT

fitted with a coaming. This opening is best of an oblong shape, and 5 in. by $3\frac{1}{2}$ in. is a good size for an A-class boat. The hatchway is fitted with coamings made from $\frac{1}{8}$ -in. mahogany, and about $\frac{3}{4}$ in. wide. These coamings



TOP VIEW OF HATCH COVER.



END VIEW OF HATCH COVER.

FIG. 61.

are glued to the deck. Owing to the camber of the deck, it may be best to put these in place after the deck is fitted.

The deck, whether dropped in or not, should have three good coats of varnish on the underside, and be put into place with white lead and brass pins. Many builders prefer to screw their decks, as in case of an accident necessitating the removal of the deck this can then be done without fear of injury to it.

In a model which has the deck dropped in, it

is necessary to fit a "covering board." Earlier in the book we explained exactly how this is done in real yacht building, and the essential difference due to size between this and model building. Now a real yacht's deck (including covering board) is flush, and if there were nothing round the edge the crew would be in danger of going overboard. Accordingly, bulwarks are fitted, varying in height with the size and class of vessel. In a racing yacht the bulwarks may be nothing more than a footrail a few inches high, and in a small racing boat it may even be a half-round mahogany beading. The part of the bulwarks that goes across the stern of the ship is known as the taffrail.

Actually speaking the covering board of a model yacht with a dropped-in deck, more or less combines the two functions of the covering board and rail round the deck, as it covers the joint between the deck and sheer strake, and prevents the water penetrating round the deck-edge. In an A-class model this would be $\frac{1}{8}$ in. thick and about $\frac{3}{4}$ in. wide. In a real yacht, teak is usually used for this, but mahogany is the best for this purpose in a model. In a model with a deck that is not dropped in, a covering board is not necessary, and some builders make a practice of carrying the paint up over the deck-edge for a corresponding distance, and thus saving weight. The addition of a beading (or rail) is, however, a nice finish to the deck. The covering board (or rail as the case may be) can be cut straight and sprung into position. It should not be glued, but must be varnished on the under side as well as the top. The best method of fitting is with copper pins. If the heads of these are nipped off before the pin is driven home, they will be practically invisible.* The deck should be finished up and varnished two coats, before the covering board is put in place. The last coat of varnish can then be put over everything.

Before varnishing the deck, the lining representing the planks will have to be put on. The method of doing this is detailed in the next chapter.

The hatch is the next consideration. Al-

HATCH COVERS

though metal hatch-rims with covers are sold, the best and simplest form of hatch is an oblong one with a hatch cover consisting of a piece of wood with an oblong slip of cork glued to its underside. The best material for the hatch cover is white wood. It is rather effective and adds nothing appreciable to the weight, if this is made in skylight form and has lines on it representing skylight panels

and guards. The cork should obviously be a good fit for the opening. It will add to the appearance if the hatch cover is made about $\frac{1}{8}$ in. smaller than the hatchway coaming all round. The parts of the hatch cover that represent glass can be left in the white of the pine, and the parts that represent the wooden framing stained dark to match the king plank. The hatch cover is shown in Fig. 61.

CHAPTER XV

Painting and Varnishing. Lining a Deck.

IT cannot be sufficiently emphasised that in the case of a racing model yacht a smooth surface may make all the difference between success and failure. Moreover, every model yachtsman wishes his craft to look smart, and a good finish adds immensely to the appearance of the boat.

In the desire to show their work, builders of planked models often varnish yachts all over, but this is not at all pretty. If two boats from the same design are built, and one is varnished all over and the other painted to the waterline, the varnished boat will look clumsy alongside her sister. The reason of this is that the waterline gives a break to the eye, which makes the boat look slimmer and more graceful. Even a painted waterline will improve the look of a varnished boat immensely. As a matter of fact, real yachts are never varnished all over. A painted bottom, narrow boot-top (the stripe along the waterline) and varnished top-sides not only looks well, but is like a real varnished yacht. The practice of planking in light and dark woods alternately is barbarous, and makes a yacht look like a mandoline. Bread-and-butter models should always be painted to protect the joints, as well as for the sake of appearance.

The colours usually employed on a real yacht below the waterline are light green, dark green, red, red-brown, dark grey, black and bronze, and those who aim at being true to the prototype can stick to these. Top-sides can be any colour, but light colours make the boat look larger. Actually, black and dark blue top sides become shabby far more quickly than white or light colours. A boot-top should be narrow, or it will look like a bull's eye when the boat heels over. Enamel must be used for white or light colours, but the builder can please himself whether he uses enamel for darker shades, or finishes by varnishing over flat colours.

There are three essentials for good results in painting and varnishing—a smooth surface to work on, good brushes and good materials.

In order to get a good surface, plenty of work must be put into glass-papering the surface beforehand. The final rubbing should be done with "flour" glass-paper. Good brushes are necessary, and are by no means cheap. Once bought, they are well worth looking after. Brushes must be scrupulously clean, and must always be thoroughly washed out after use. New brushes should be well soaked in cold water before use to make the hair swell and prevent it coming out. After use, brushes can be cleaned with turpentine or paraffin.

One of the great difficulties in painting and varnishing is that dust settles on the work, and care should be taken to avoid leaving the work in a dusty place during drying. So much importance is attached to this that at a certain large firm of Continental yacht builders, where a very fine finish is put on all work turned out, there is an airtight room for varnishing. Before work is done in this, the place is sprayed to keep down any dust.

As regards the paint used, the priming coats can be of white lead ground in oil, mixed with turpentine, and a little varnish. After the priming, a couple of coats of good white lead or zinc paint can be given. The enamel used should be a first-rate brand, and can be preceded by a couple of coats of whatever undercoating is recommended by the manufacturers. Any varnish used should be one of the best yacht varnishes.

Before starting to paint, the hull should be carefully gone over and stopped wherever necessary. If a good job has been made, there should, however, be very little need for this. White lead putty can be used for stopping or, better still, a stopping can be made of white-lead powder mixed with gold size. If the waterline falls on one of the joints of a bread-

PAINTING A HULL

and-butter boat, a series of dots an inch apart should be made round this, using a sharp-pointed copying pencil. These dots will show through the paint, and will serve to mark the waterline.

The first priming coat can now be applied, and the paint for this can be "sharp." The term "sharp" is used by painters to denote a paint that has little or no oil in it and dries quickly. The paint should be thin, to penetrate well into the wood and form a key for subsequent coats. After the priming coat is dry, the hull should be gone over again, and any place that has not been properly stopped should be attended to. The hull can now be rubbed down again, using a medium grade of "Wet-or-dry" paper. This is a special kind of flint paper made for high-class painting. It is used wet. The paper is dipped in water before applying to the work. This prevents it picking up the paint, and gives a much smoother finish. The secret of using this is to keep the work wet all the time.

After rubbing down, another coat of priming is given, and the boat again rubbed down. Care must be taken that each coat of paint is thoroughly hard before any rubbing down is attempted or another coat applied.

Two coats of white lead or zinc are now given, the boat being rubbed down after each. Between each coat the spots representing the waterline should be gone over with the pencil. If the boat is planked, or the waterline does not fall on any of the joints, the best method of getting the waterline level is to carefully chock the boat up on a smooth table. Be sure that she is dead level, and then, using a scribing block, put in the waterline. If the builder has not got a scribing block, it is not a difficult matter to improvise something that will answer the purpose.

The undercoatings have now to be applied. As it is necessary to use different colours for the top-sides and bottom, preparation must be made to keep these apart. If the yacht has a boot-top, it is best to put this in at this point, and the width of the boot-top will then serve to keep the top-sides and bottom apart. The method of getting a sharp edge to the

colours is to stick slips of paper along the waterline so that the paint can be easily carried right up to the edge of the paper without fear of over-running the division. The paper slips are put on with paste or gum, so that they can be readily washed off when finished with. After getting the gum paper into position, it saves trouble to go right ahead and finish one part of the yacht right off. The paper is then soaked off and a fresh lot put into position for the other part of the boat. As the different coats are put on, the boat is well rubbed down, using finer grades of the Wet-or-dry paper.

Two coats of enamel are given. After the first, the yacht is rubbed down with the finest possible wet-or-dry paper, and the last coat is applied. By way of finishing off, the enamel is rubbed down with a damp chamois leather and very finely-ground whiting.

If the model has been well rubbed down between coats and the paint applied in thin coats, the finished result should be something to be proud of.

In varnishing a boat, the first coat should be half turpentine mixed with the varnish. This will sink well into the wood and act as a filler. After this the boat is rubbed down with the Wet-or-dry paper. In a varnished boat, any stopping used should be carefully coloured to match the wood. Cabinet makers use a wax that can be bought in sticks like sealing wax. This is melted with a hot iron and run into the place to be filled. This is quite satisfactory for stopping a small place, like a worm-hole in mahogany, but should not be used for anything big. At least three coats of varnish should be given, preferably four. The brush should be used in the same way as when working enamel. That is to say, it should be brushed in one direction only, *not* backwards and forwards.

The old saying was "Paint thin and varnish thick." Whilst the first part is correct, the second is misleading. Coats of varnish should only be just thick enough to flow evenly. If put on too thick, varnish runs in waves, and then it requires endless rubbing down to make it come anything like right.

After the final coat of varnish, the chamois

MODEL SAILING CRAFT

leather and ground whiting can be used for a light rub-down.

* * * *

If the yacht is a new one, the lining is best put on to the deck before it is fitted, and in fact before the reinforcement pieces are put on to the underside. In preparation for lining, the deck is given a couple of coats of clear size, to prevent the Indian ink (with which the lining is done) from running. It is then rubbed down very lightly with fine glass-paper.

The lines are put in with a draughtsman's ruling pen. There are two systems of lining. The first is with parallel straight fore-and-aft lines, but this is not used for best work. The best decks are laid in narrow planks, running parallel with the deck-line. These curved lines are very difficult to put in nicely unless the proper method is employed. A marking gauge is arranged to hold the pen, and, using the deck edge as a guide, the planks can then be put in without any undue difficulty. When a deck is

laid in this manner it has a king plank running down the centre. In a real yacht this is usually made of teak or mahogany, which furnishes a contrast to the pine of the remainder of the deck. Fig. 62 will make this quite clear. In the model the centre of the deck, which represents the king plank, can be stained to match the mahogany covering board or rail. This is shown in the diagram, where the king plank, rail and hatch coaming are shown in black.

After the deck is lined, it should have a coat of varnish to prevent the lining being marred during subsequent operations. The reinforcement pieces and coamings can then be fitted and the underside varnished.

After the deck has been fitted, the covering board should be put on and the deck should receive two more good coats of varnish.

If it is required to line out the deck in position on the model, this can be done in the same way. It is not quite so convenient as doing the job before the deck is put into place, but with a steady hand should present no great difficulty.

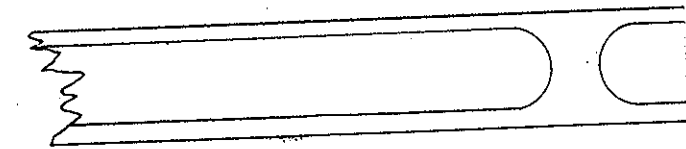


FIG. 63.—SECTION THRO

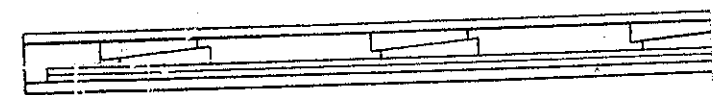


FIG. 64.—HOLLOW SPAR MAKING, SHOWING

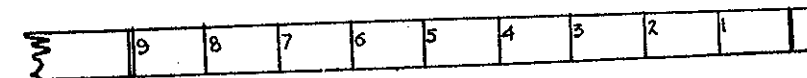


FIG. 65.—METHOD

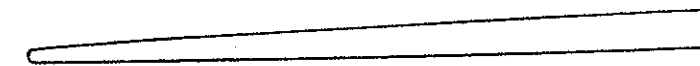


FIG. 66.—

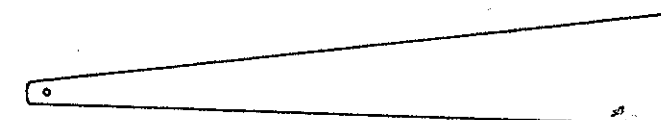


FIG. 67.—THE BES

The above Figures are fully explained in Chapter XVII., in which methods

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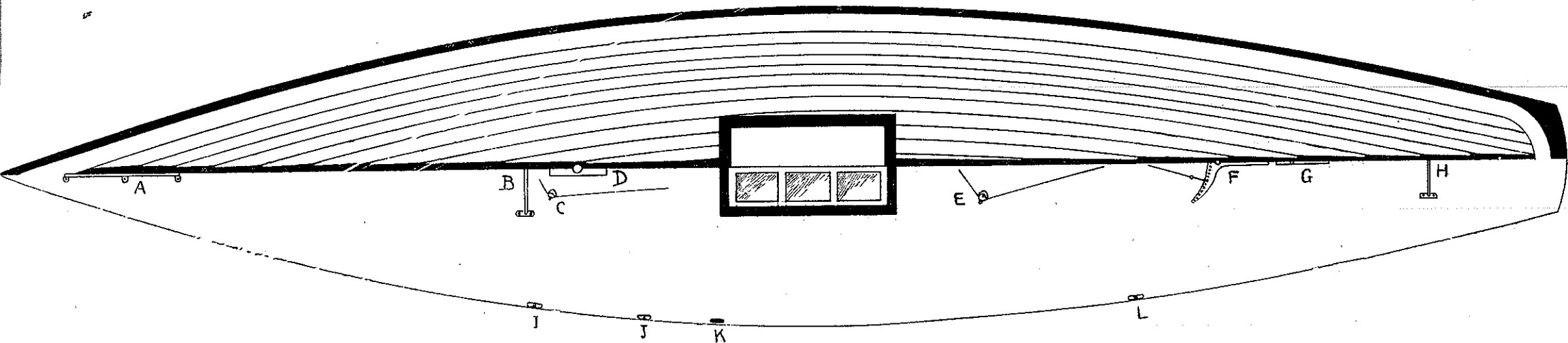


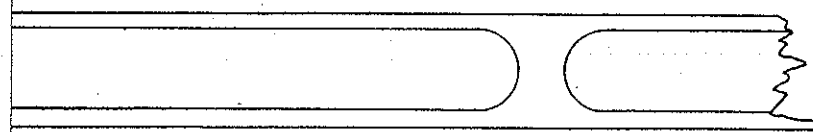
FIG. 62.—DECK PLAN.

Starboard Side (R.H. side looking forward).—Shows method of lining the deck to represent planking. The black edge to the deck is the mahogany rail, the part going across the stern being the taffrail. The broad plank all round the deck just inside this represents the covering board. The black part up the centre of the deck is the king-plank, and the black edge to the hatchway shows the hatch coamings.

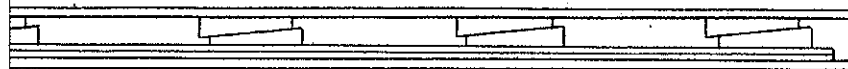
Port Side (L.H. side looking forward).—Shows arrangement of the deck fittings, including the hatch cover, the portion of the hatch coaming that shows round the cover being shown in black.

The other fittings are :

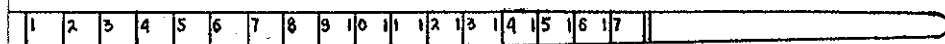
- A.—Jib-rack.
- B.—Fore Horse.
- C.—Jib Steering Block.
- D.—Mast Slide.
- E.—Main Steering Block.
- F.—Quadrant.
- G.—Tension Slide.
- H.—Main Horse.
- I.—Gunwale Eye (for Spinnaker Boom Hook).
- J.—Gunwale Eye (for Shrouds).
- K.—Spinnaker Sheet Hook.
- L.—Gunwale Eye (for Beating Gye and Spinnaker Back-haul).



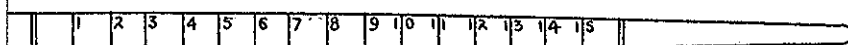
ROUGH HOLLOW SPAR SHOWING THE WEBS.



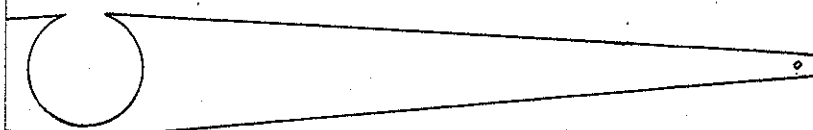
SPAR WEDGED INTO JIG DURING GLUEING-UP OF TWO HALVES.



OF CALIBRATING A MAIN BOOM.



CALIBRATION FOR JIB-CLUB.



T METHOD OF MAKING SPREADERS.

of spar making and calibration, also construction and fixing of spreaders, are fully detailed.

[To face page 129.

CHAPTER XVI

How to Fit the Braine Steering Gear—Vane Steering Gear.

THE earliest model yachts had no steering gear whatsoever, and consequently were unable to sail a good course when the wind was anywhere abaft the beam. The first steering gears to come into use were

that the yacht keeps a dead-straight course. A straight line is the shortest distance between any two points, and, obviously, the helmsman who sails the straightest course is going to gain much ground on his rivals.

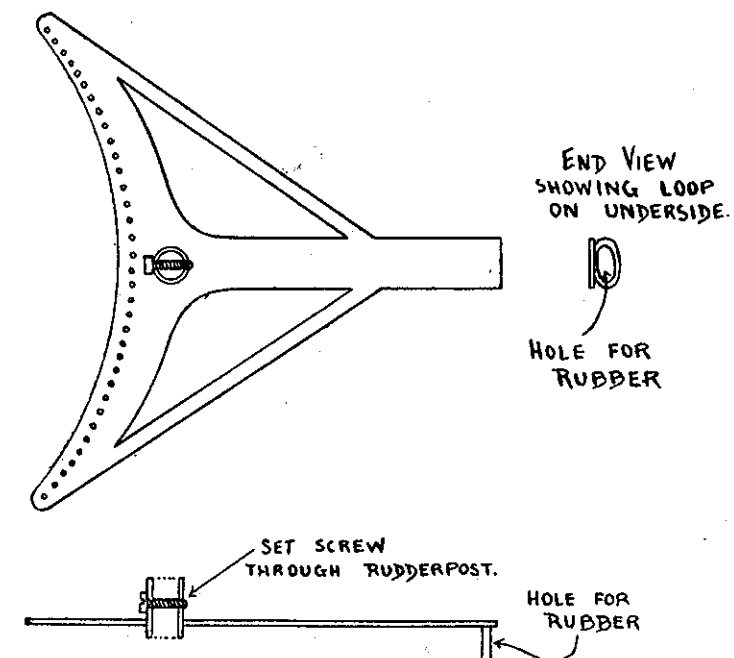


FIG. 68.—BRAINE QUADRANT.

weighted rudders, and though these were better than nothing at all, it was not until 1906 that a really efficient steering gear was invented, and with its invention model yachting at one stride advanced from being a more or less childish pastime to a sport calling for great skill and accuracy.

Now, in theory the main function of the rudder is not to hold a yacht on her course, but to steer her back to her course when she is thrown off it by a puff of wind. Actually, in practice, the helm does hold the boat on her course, and with a good helmsman every variation in the wind is anticipated and met, so

It would, therefore, seem to be an absolutely correct principle in models to make the very factor that tends to throw the yacht off her course actuate the rudder to keep her straight. Several attempts were made to do this, and in 1906 Mr. George Braine of Kensington evolved the steering gear for models which bears his name. By this gear, the angle of the rudder can be made to vary in exact ratio to the pressure of the wind on the sail. During the years that have elapsed since its invention, minor improvements have been made in the pattern of the quadrant and by the substitution of a slide for the pinrack with

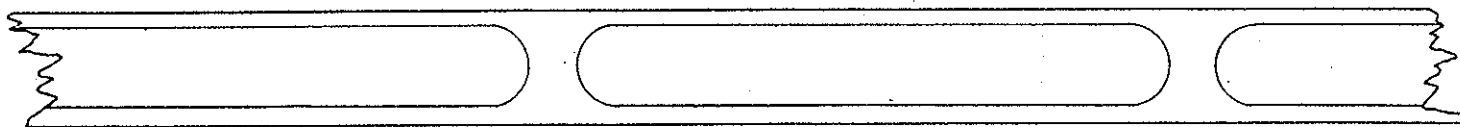


FIG. 63.—SECTION THROUGH HOLLOW SPAR SHOWING THE WEBS.

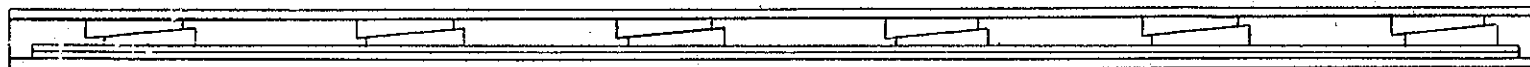


FIG. 64.—HOLLOW SPAR MAKING, SHOWING SPAR WEDGED INTO JIG DURING GLUEING-UP OF TWO HALVES.

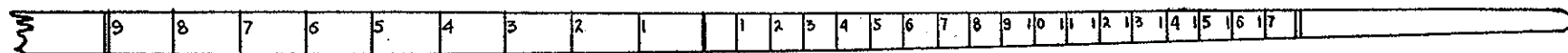


FIG. 65.—METHOD OF CALIBRATING A MAIN BOOM.

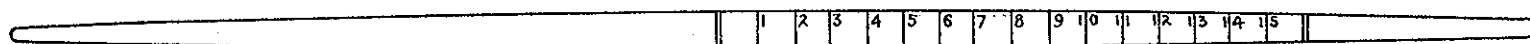


FIG. 66.—CALIBRATION FOR JIB-CLUB.

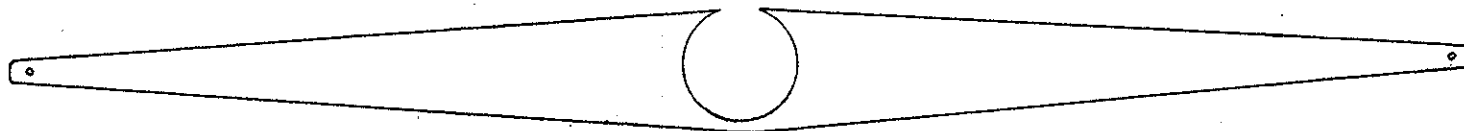


FIG. 67.—THE BEST METHOD OF MAKING SPREADERS.

The above Figures are fully explained in Chapter XVII., in which methods of spar making and calibration, also construction and fixing of spreaders, are fully detailed.

MODEL SAILING CRAFT

which early gears were fitted. The principle of the gear, however, remains absolutely unchanged.

The method of using this gear will be found in the chapter on Sailing, and we are here concerned mainly with the way to make it and fit it up. At the same time some little explanation at this point may be of assistance to the builder in making and fitting the gear correctly.

The principle is briefly that as the wind freshens the yacht tends to head up towards the wind. In a full-sized vessel the helmsman corrects this by giving the yacht weather helm. In the model the pressure of the wind on the sail causes it to pull on the sheet, which is attached to the helm and thus operates the rudder. There is an elastic centering line to bring the rudder back amidships. As the pull of the sail must operate through the weather sheet, the steering lines are accordingly crossed.

The gear itself consists of a quadrant attached to the rudder-head, a pair of pulleys, a tension slide, and an elastic centering line. The first essential of any steering gear is that the rudder shall move freely. To ensure this, the pintle must be properly made and fitted, as described in Chapter XIV., and the rudder-post must not bind in the rudder-tube. Care should be taken that no paint or varnish gets inside the rudder-tube, as nothing will cause a

deck can be seen in Fig. 62. It may be mentioned that the set of gear shown in Figs. 68, 69, 70 and 71 is drawn relatively to scale,



FIG. 69.—PULLEY.

being half size for a Braine gear for an A-class model.

The quadrant of an A-class boat (see Fig. 68) will measure about 4 in. from back to front, and about 5 in. across. It will be smaller proportionately for the smaller classes. The radius of the curve of the forward part is approximately $4\frac{1}{2}$ in., and the holes for the hooks are spaced $\frac{3}{16}$ -in. centres. A wire loop is hard soldered on the underside of the tail to take the rubber centering line as shown in the end view given in the diagram. In order to take the rudder-post, the quadrant carries a sleeve $\frac{5}{8}$ in. long. This is hard soldered to the quadrant, and has about half its length below it. The sleeve must be a close fit for the rudder-head. A set screw passes through

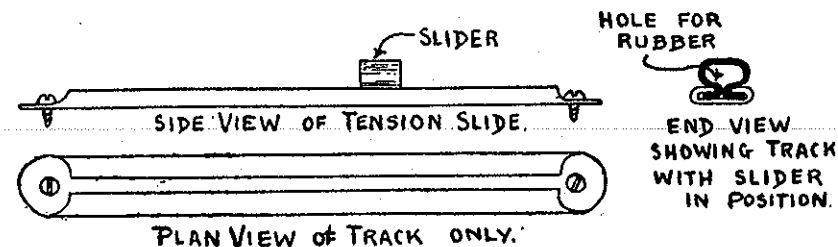


FIG. 70.—THE TENSION SLIDE.

rudder to bind more. Another point of the utmost importance is that the pulley blocks must run very freely and that the steering lines must render easily through them.

The various parts of the Braine gear are shown in detail in the diagrams illustrating this chapter, and their arrangement on the

sleeve and rudder-head, and prevents the quadrant from wringing round. It is essential that the rudder and quadrant be very carefully lined up when drilling the hole for the set-screw, as if the rudder is the least fraction out of central the boat will not sail properly.

It will be noticed that the quadrant illus-

THE BRAINE STEERING GEAR

trated has side webs. Although these are advisable in a large quadrant such as fitted to an A-class model, they can be dispensed with for smaller sizes.

The construction of the pulleys can be seen from Fig. 69, and it is sufficient to add that they must be of ample size to take the cord used for steering lines, and also run very freely.

The slide consists of a base piece with the edges turned up, as shown, to form a track, and the slider. The slider must move easily, and

In a Braine gear for a square-sterned boat the tail for the centering line will be ahead of the rudder, as shown in Fig. 71. The quadrant in this case is set higher than the tail with the set-screw that goes through the rudder head in between them.

The hooks for the steering lines are shown in Fig. 72. This form of hook is used to facilitate quick adjustment.

When the quadrant has been fitted, the rudder is put central and a screw-eye put into the deck abaft the rudder. This screw-eye should be opened up to form a hook for the rubber centering line. A suitable length of rubber cord is now cut off to form the centering line. For an A-class model this will be

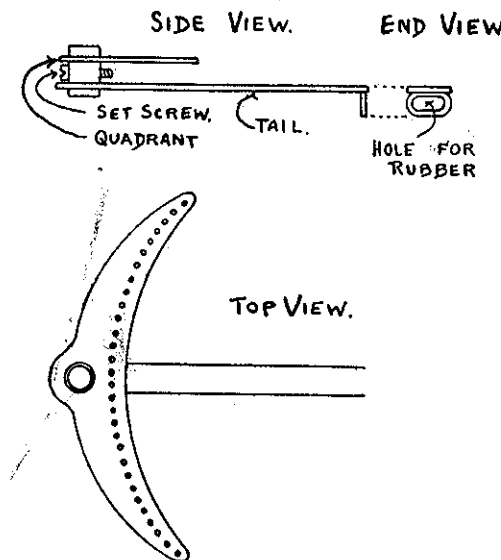


FIG. 71.—QUADRANT USED ON SQUARE-STERNED BOAT.

yet not so freely that it will shift of its own accord. The method of making this should be quite clear from Fig. 70. In the end view, the slider is shaded black for the sake of clearness. Some skippers fit a double slide. This consists of two tracks and two sliders. The rubber cord passes between these, and when they are level in a fore-and-aft direction the cord cannot escape from between them. They have the advantage that a different tension and adjustment can be given on each side. They are also useful for trick sailing round the corner of a pond, as the rubber can be slipped to one side to give a permanent helm. Their use is not to be recommended to novices, however.

$\frac{3}{16}$ -in. diameter. The rubber is used double. The ends are lashed together, and the cord middled and hooked on at the stern. It is then passed through the eye in the quadrant, and one part passed on each side of the rudder post under the quadrant. The quadrant will have to be taken off whilst this is being done. A cord with a bowser is fastened to the forward end of the centering line to allow for its adjustment. Carefully line up and put a screw-eye into the deck to take the forward end of the centering line. The slides have now to be put in place. In the case of a single slide, the rubber passes through the hole in the slider, but in the case of double slides it passes between them. In putting the slides into position, great care must be taken that they do not give the rudder a bias either way. The slides should be so placed that when in the most forward position the slide is within $\frac{1}{16}$ in. of the tail of the quadrant.

The steering pulleys have now to be fixed. These should be sufficiently far apart to ensure the leeward line remaining idle if the boom rises somewhat in a heavy wind.

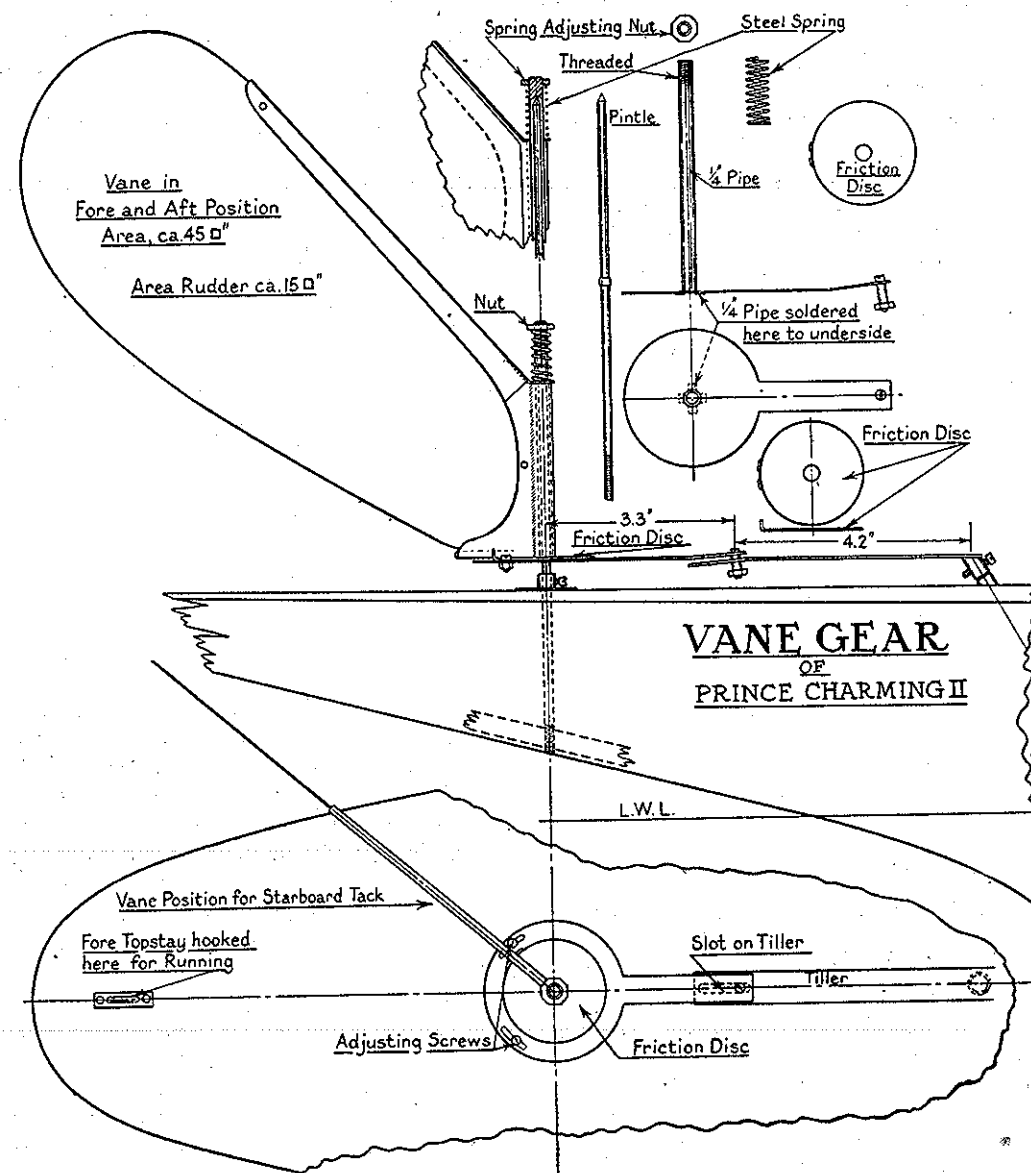


FIG. 73.—VANE STEERING GEAR, AS USED ON "PRINCE CHARMING II." (INTERNATIONAL A-CLASS CHAMPION, 1935 AND 1937).

The fitting up of the running lines is detailed in the chapter on Running Rigging.

The Braine gear is often fitted to work on the jib as well as the mainsail. To arrange this, all that is required is an extra pair of

pulleys and two more hooks. The arrangement of these is shown in Fig. 62. The uses of jib steering are fully explained in the chapter on Sailing a Model.

The only other steering gear in use nowadays

is the Vane gear, which differs considerably in principle from the Braine gear. The rudder in this gear is controlled by a vane directly actuated by the wind, and is entirely independent of the sails. In open water sailing this gear has proved very effective, but its value for pond sailing is more problematical.

With this gear a yacht can sail extremely close without fear of getting in irons, but as the setting is different for the two tacks, the vane has to be put over each time the boat is tacked. Again, when the gear is used in lieu of a guy for short tacking, its action is so sudden that it is extremely difficult to gain any offing at all.

Down wind this gear is far too sensitive and liable to be affected by the back draught from the sails with the result that the yacht yaws about considerably instead of keeping a steady course. The only skipper who has used this gear with outstanding success is Mr. Sam O. Berge, of Norway, who won the International A-class races in 1935 and 1937 with his "Prince Charming II." fitted with vane gear. It should be mentioned that this gear is barred in the United States.

The vane gear was used by the world-renowned American yacht designer, Nathaniel Herreshoff, in 1875 on models used for experiment. The gear illustrated in Fig. 73 is that

used by Mr. Berge, and with a few slight modifications identical with Mr. Herreshoff's.

The vane is clear celluloid with a brass frame or stiffener fitted as a sleeve along the leading edge and foreside. The vane shaft is of $\frac{1}{4}$ in. light brass tube soldered to a disc or quadrant carrying the connecting rod or lever which actuates the tiller, the latter being aft of the rudder-head. The friction disc is placed on the vane shaft on top of the quadrant. At the top of the vane shaft is a steel wire spring (a spring from an old cycle pump is about right), adjustable by a nut to give sufficient pressure on the disc to hold the vane to any desired angle. It will be noticed that there are two small screws to adjust the limit of the vane's movement when beating. For reaching and running it is necessary to lift the vane sufficiently to pass over these screws. The whole gear is hung on a pintle as shown in the drawing, and there is a minimum of friction on all moving parts.

It should be noted that the area of the vane must be approximately three times that of the rudder it is to actuate.

We are indebted to Mr. Sam O. Berge for permission to reproduce his drawings of this gear. Notes on its use are included in the chapter on Sailing.

CHAPTER XVII

Spar Making. Hollow Masts. Calibrating a Boom. Spar Fittings: Spreaders, Jenneys, Goosenecks, Jib Ferrules, Spinnaker Fittings. Deck Fittings: Mast Slides, Chainplates, Jib Racks, Horses, Gunwale Eyes, Spinnaker Sheet Hooks. Bowsprit Fittings. Soldering and Silver Soldering.

SPAR MAKING

IN spar making, the first consideration is the material. For models there is nothing better than a well-selected piece of pine. This should have a nice long even grain, and be clear and free from knots or waves in the grain.

Having selected the wood, it should be cut to a square and planed up true. Many models have unnecessarily heavy spars, and, provided the mast is well stayed, the thickest part of a mast for an A-class boat need not be more than $\frac{3}{4}$ in. A hollow spar will require to be a trifle larger in diameter. For an A-class boat, $\frac{7}{8}$ in. will be suitable. The part of a mast below deck receives very little side strain and therefore can be quite light. The greatest strain comes about half-way up from the deck, and the mast should be at its thickest at this point. The thickness at the deck will be about the same as that two-thirds of the way up, and below and above these points it will taper away to about $\frac{5}{8}$ in. at the heel and $\frac{1}{2}$ in. at the truck. In order that the sail may set properly, the after side of the mast must be straight, so all the taper will be on the fore side. Similarly, the boom is straight along its top side and the taper given on the underside.

The thickest part of the boom will be about the middle, and the same applies to the jib-club. The term "jib-boom" is often applied to the spar which runs along the foot of the jib, but the jib-boom is more properly the boom which forms a continuation of the bowsprit in a square-rigged ship on which the jibs are set. The term "jib-club" is, therefore, more correct.

The first step in making a spar from the square piece of wood is to mark on the sides the thickness from the straight side. In other words, if the spar is a mast, having determined

which is to be the after side of the mast, the thickness is then set off on the edges, which will eventually be the port and starboard sides. If a curve is struck through these points, the spar can then be planed down, and will be correct in profile as seen from the side. A centre line is struck with a marking gauge down the fore side of the mast and also down the after side. The taper is marked from this centre line and the faces planed down. The spar should now be square in section throughout. The corners are next planed off making the mast octagonal. The spar is then rubbed down with coarse glass-paper until it becomes round and finished off with fine. It should be noted that when marking the square for planing a small allowance must be made for the glass-papering, as otherwise the spar may come out less than the required dimensions.

HOLLOW SPARS

The weight of a solid mast for an A-class model is about 15 oz., and that of a hollow mast about 9 oz. It will, therefore, be seen that a hollow mast will save 6 oz. This may seem very little in comparison with the total weight of a boat of this class, but it must be remembered that the height of the mast gives it a great leverage, and an ounce saved aloft is as good as several ounces of lead in the keel from the point of view of stability. Against this must be set the fact that it has to be of slightly greater diameter to have the necessary strength. The increase in the mast of an A-class boat would be about $\frac{1}{8}$ in. On the whole, the advantages may be said to outweigh the disadvantages considerably, provided the builder is prepared to go to the extra trouble involved. The question of a hollow boom is an altogether different matter owing to the fact that the boom is low and

MAKING HOLLOW MASTS

further, many authorities do not consider an abnormally light boom to be advantageous, as it rises too easily. This must not be taken as an advocacy of an over-heavy boom, but simply an expression of opinion that a hollow mast and a solid boom are the best combination to use under normal circumstances.

The best and easiest method of making a hollow mast for a model yacht is to build it from two pieces of wood. Two pieces of pine a little thicker than half the thickness of the finished spar and of slightly more than the breadth are required. These are planed up ready for marking. Before commencing, it must be mentioned that the joint between the two halves of the mast is going to be fore-and-aft on the centre line of the yacht. The taper is marked out on each half for the fore side of the mast, and they are clamped together and planed down. As a guide for the hollowing out, the faces of the two halves can be marked with the taper the spar will eventually have, but the hollowing out must be done before any further shaping is done on the outside.

The mast will not be hollowed out from end to end, but at intervals solid pieces are left somewhat after the fashion of the knots in a bamboo. These solid portions are known as "webs." The top 5 or 6 inches of the mast will also be left solid, and the bottom portion up to the gooseneck. It must be arranged that webs fall wherever a fitting has to come on the mast. The principal places are the spreaders, the jib halliards and the hounds for the lower shrouds. These places should be carefully marked out. The intermediate webs can be about 5 in. apart. Before starting to hollow out the inside, the inner faces of the two parts of the mast must be carefully marked out with the thickness to be left for the walls.

The inside is now hollowed out with a suitable sized gouge, and the inside can be smoothed down with glass-paper wrapped round a piece of stick. The two halves are now ready to be glued together. In hollowing out, the walls of the mast should be left about $\frac{1}{8}$ in. thick for an A-class, and $\frac{1}{10}$ in.

for a 6-m. Section of a hollow spar showing the webs is shown in Fig. 63.*

For glueing up the mast, casein glue should be used, and a suitable arrangement will have to be made to clamp the two halves together. To make the jig for glueing up the two parts of the mast, a piece of wood the length of the mast and 4 or 5 ins. wide is required. Along each edge screw a batten about an inch square. The distance between the battens should be about 2 in. The mast is glued together and laid in the trough between the battens and against one of them. In order to obviate any possibility of the mast sticking in the jig through any glue running out of the joint under pressure, the trough should be lined with paper beforehand. The mast is then wedged firmly together. Pairs of wedges are used so as to exert an even pressure. These are placed every 8 in. or so. The arrangement is clearly shown in Fig. 64.* The mast will, of course, be put into the jig with the straight back downward and the shaped foreside uppermost. After the glue is thoroughly set, the mast can be removed from the jig and the shaping proceeded with as if the mast was solid.

Metal Masts.—Masts for models can be had made of duralumin and steel. Owing to the nature of the metal, it is necessary to make the duralumin masts of thicker gauge than the steel, so that there is little or nothing to choose between them as regards weight. The weight of a metal mast is about the same as a hollow wooden mast, but the metal mast is a decided advantage in some respects.

A metal mast has much less windage surface than a hollow wooden mast, and is also stronger. On the other hand, it is beyond the power of an amateur builder to make a metal mast, and these must be purchased.

Duralumin masts are made up of several different diameters of tube jointed one into the other. Aluminium alloys are hard to solder and special materials have to be used, and therefore the collars for the mast fittings are usually arranged to fall at one of the joins between the different diameters of tube used.

* See back of folding plate inserted in Chapter XV.

On the other hand, steel masts can be had nicely tapered, and there is no difficulty in sweating the collars for the fittings to the mast in any desired position. The sole disadvantage of steel masts is their liability to rust, and they should be kept well painted. The usual place where a steel mast rusts through is at the mast slide, where it chafes against the metal of this fitting and removes the paint. This can be avoided by the use of a little piece of rubber tube slipped on to the mast at this point, or it can be protected with adhesive tape.

man's ruling pen. The method is to push the end of the spar against the point of the screw and revolve it with the left hand whilst holding the pen firmly against the spar with the right. The boom is thus revolved as if it was in a primitive form of lathe whilst the marks are put in for the calibrations. As soon as these are dry, the necessary figures are put in with an etching pen. The figures should appear on each side of the spar rather above the middle, so that they can easily be seen. The after end of a main boom showing the cali-

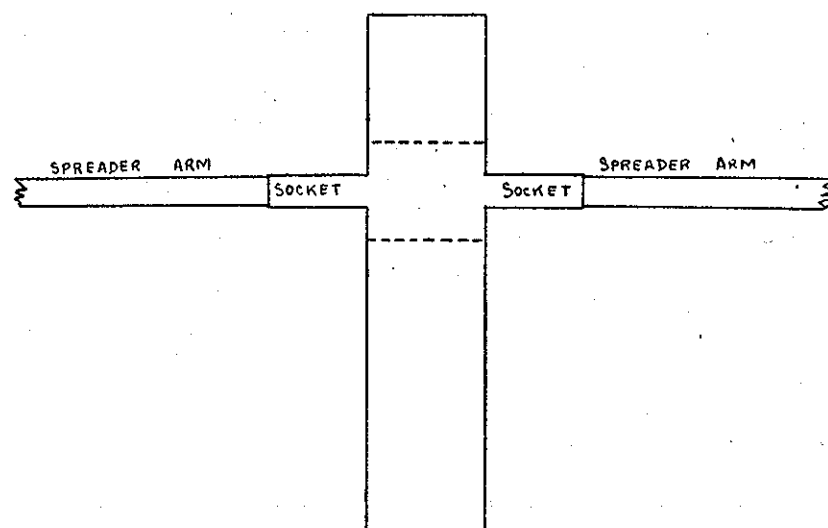


FIG. 74.—FERRULE FOR JOINTED MAST EMBODYING SOCKETS FOR SPREADER ARMS. THE DOTTED LINES SHOW BAND USED TO CARRY SPREADER ARMS WHEN MAST IS NOT JOINTED.

Calibrating a Boom.—It is customary to calibrate the booms of racing models. The object of this is that having found the correct sail trim it can be repeated with certainty as many times as required.

The spar to be calibrated must be prepared by giving a couple of coats of clear size, rubbing down lightly after each with very fine glass-paper. The intervals should first be marked on the spar in pencil from a rule. A piece of wood of suitable size is then fixed at one end of the bench. Into this a screw is driven with its point coming through the wood and projecting. The calibrations have to be put on with Indian ink and a draughts-

man's ruling pen. The method is to push the end of the spar against the point of the screw and revolve it with the left hand whilst holding the pen firmly against the spar with the right. The boom is thus revolved as if it was in a primitive form of lathe whilst the marks are put in for the calibrations. As soon as these are dry, the necessary figures are put in with an etching pen. The figures should appear on each side of the spar rather above the middle, so that they can easily be seen. The after end of a main boom showing the cali-

SPAR FITTINGS

After making the spars, it is necessary to make the fittings. Their arrangement will be seen in the figures illustrating the chapter on Rigging.

Spreaders.—There are several ways of making and fitting these.

When the mast is in one length, the simplest and best method is to make the spreaders as shown in Fig. 67.* A suitable piece of $\frac{1}{2}$ in. Italian walnut is required. In this bore a hole

* See back of folding plate inserted in Chapter XV

that just fits the mast at the required spot. It will be noticed from the plan view of the spreaders that they do not extend right round the mast, but the ring is broken on the after side. When the spreaders are shaped, a small hole is drilled in each end for the wire

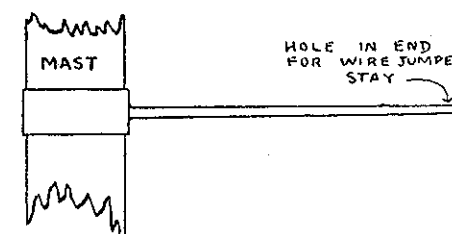


FIG. 75.—METHOD OF MAKING A JENNY (see Text).

shrouds. Alternatively a notch can be cut for the shrouds at each end. In order to prevent the wires splitting the spreaders, a small screw is put into the spreaders at the inner end of each notch. The notches can be $\frac{1}{8}$ in. deep. A suitable length for the spreaders of an A-class model is about 10 in. over all. When the spreaders are finished and have been varnished, they can be put into position on the mast. A small screw can be put through the

the mast is made to take into two parts for travelling. In this case it can be incorporated with the tube which forms the joint. This is illustrated in Fig. 74.

Jennys.—The jenny is the short strut forward of the mast which extends the jumper stay. The jumper stay is the stay which prevents the topmast from bending aft and also keeps the mast from being bent forward by the forestay or jib halliards.

There are several methods of fitting the jenny. One method which is not to be recommended is to make the jenny from a piece of small brass rod and socket the end into a hole in the mast. The outer end in this pattern is flattened a little and has a hole bored through it to accommodate the jumper stay. A second method is to have a metal collar round the mast with a metal jenny hard soldered to it. A third method is to have a socket on the collar and use a wooden jenny. Of these methods the second is by far the neatest (see Fig. 75).

Goosenecks.—The gooseneck is the hinge on which the boom swings. In a real yacht the gooseneck proper is the fitting on the end of the boom. It consists of a ball-shaped joint,

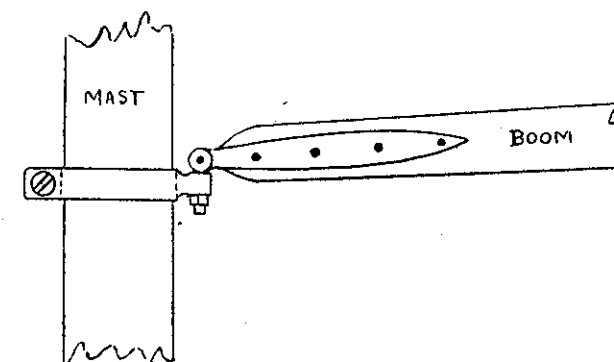


FIG. 76.—THE PROTOTYPE FORM OF GOOSENECK.

fore side into the mast. The spreaders are then firmly seized into position with stout linen thread. When the seizing is finished, it is well varnished to preserve it from the water.

Another method is to have a collar round the mast with suitable sockets for the spreader arms. This is particularly appropriate when

allowing the boom to swing upwards. The boom is held between two plates which are screwed firmly to the boom. The gooseneck has a round rod like a bolt with a nut on the bottom. This goes through a socket on the mast-band and permits the boom to swing sideways also. This arrangement is shown in

Fig. 76. For prototype models this is a very suitable arrangement and has the merit of exactly following the original.

The best form of gooseneck for use in heavy models like an A-class is shown in Fig. 77. An alternative form of gooseneck, as Fig. 78, is easier to make and quite efficient for smaller racing models. One of these two types is recommended for all models except those that aim at being true to the prototype in every detail, and these should follow Fig. 76.

Jib Ferrules.—The jib ferrule consists of a

the ordinary type of jib-club along the foot of the sail. There is another method of using a jib-club as a "radial boom." By this method only the clew of the jib is made fast to the boom. The tack of the jib is hooked directly on to an eye in the deck, whilst the fore end of the boom is pivoted on the deck slightly aft of the tack of the sail. The foot of the sail is then longer than the boom, and as the radius of the circle described by the boom is shorter than that of the foot of the sail, it is obvious that as the sail is eased off, the foot of the jib

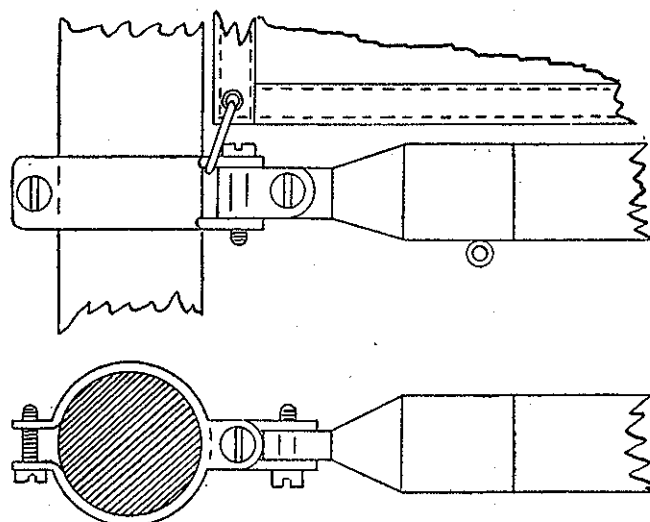


FIG. 77.—GOOSENECK USED ON LARGE RACING MODELS.

metal cone with an eye hard soldered into its tip. The tack of the jib is made fast to this, also the forestay. A second eye is fitted on the underside of the ferrule to take the tack-hook for the jib (see Fig. 79). It used to be customary to have the tack-hook some distance back from the actual tack of the sail. The idea of this was to keep the sail flat by preventing the clew from lifting. Actually this prevents the sail taking its natural curve and takes all the power out of it. It also converts it from a lifting sail to a pressing sail. To-day the tack-hook is only the least bit back from the fore end of the boom, and the pulling power of the sail is greatly enhanced accordingly.

The ferrule described above is suitable for

becomes looser and allows the sail more flow. As it is brought inboard, the reverse takes place, and when the sail is sheeted close in, the foot is taut. This gives the advantage of more flow in the sail for reaching and running. This form of sail has been tested, but not fully tried out. For a radial boom, the eye in the bottom of the ferrule is unnecessary, and the eye at the end would be hooked on to an eye in the deck. An illustration of this will be found in Fig. 100, which, taken in conjunction with the above explanation, should make the principle of the radial boom perfectly clear and also show the fittings required.

Main Boom Ferrules.—In order to make a neat finish to the boom, most builders fit a

ferrule to the outboard end. This carries two or four eyes. If the two-eye pattern is used the small upper eye takes the clew outhaul and the larger lower one the jackline, the beating guy being hooked into the lower also

Mast Slides.—In order to permit of fine adjustment of the rig in a fore-and-aft direction, it is usual to fit a racing model with a mast slide. The advantage of this arrangement is that it permits the yacht to be tuned up

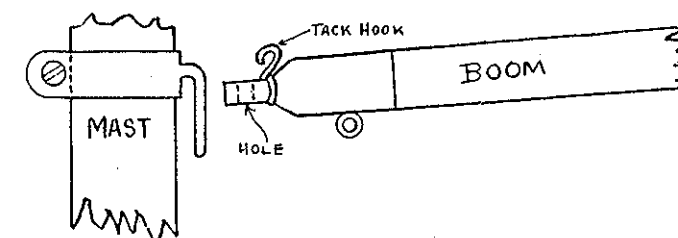


FIG. 78.—ALTERNATIVE FORM OF GOOSENECK FOR SMALLER SAILING MODELS.

when required. The four-eye pattern has all the eyes the same size and the beating guy hooks into the side eyes. This pattern is illustrated on the end of the boom in Fig. 101. The two-eye pattern is, however, recommended as less liable to become foul in cases of collision.

Spinnaker Fittings.—In a real yacht the spinnaker boom has a gooseneck similar to that on the main boom, but is only shipped as needed. To accommodate the spinnaker boom the mast has a second mastband of a smaller size above the main mastband.

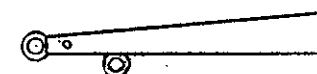


FIG. 79.—FERRULE FOR JIB-CLUB.

Owing to the fact that such small spinnakers as can be used on even the largest size model have a tendency to sky (balloon up to the masthead, lifting the boom), another method of setting the spinnaker has been found for racing models. This is fully explained in the chapter on Rigging.

DECK FITTINGS

From the spar fittings we next proceed to the deck fittings. Their arrangement will be clearly seen on reference to Fig. 62, which gives a suitable lay-out for the deck of a model racing sloop.

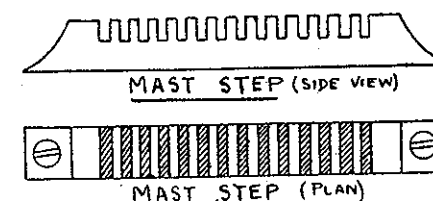


FIG. 80.—MAST STEP FOR USE IN CONJUNCTION WITH MAST SLIDE (see Text).

apart. The lower face of the brass square is left about $\frac{1}{4}$ in. longer each end than the others, to permit of holes being made to take the screws that hold it to the keelson (see Fig. 80).

In order to fit this step, the foot of the mast has a notch cut in it. A brass collar fits round the mast heel, and a screw is put through from side to side to ride in the slots in the step. The slots in question should be just sufficiently wide to accommodate the screw comfortably. This arrangement can be clearly seen in Fig. 81.

The mast slide itself consists of a plate screwed to the deck. This has a hole through it of a width sufficient to clear the mast at this point. The length of the hole gives the

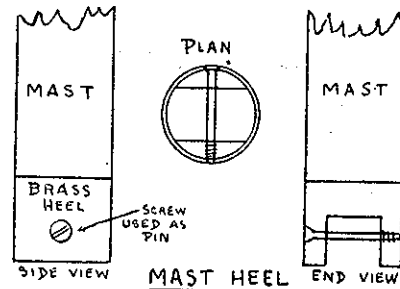


FIG. 81.—MAST HEEL ADAPTED TO FIT MAST STEP ILLUSTRATED IN FIG. 80.

range of movement in a fore-and-aft direction. The edges of this plate are turned over so as to form a slide in which the plate carrying the mast tube moves. The moving part of the

deck. A series of holes are drilled in each side of the sliding plate so as to register with the two holes in the deck plate. By inserting a pin, the sliding plate can be locked into any desired position. The holes in the sliding plate are spaced $\frac{1}{8}$ in. apart to correspond with the slots in the mast step. It will be noticed in the drawing that the holes on one side of the sliding plate are spaced midway between those on the opposite side. This permits the whole mast to be moved by eighths of an inch, and, at the same time, provides a fine adjustment to the rake. The slide, slide plate and pin are shown in Fig. 82, and its uses should be quite clear.

Chainplates.—In small models the strain on the shrouds is not very great, but when it comes to a big heavy model, such as an A-class, the pull on the weather shroud in heavy weather is very considerable. Most builders use a gunwale eye (see Fig. 88) in lieu of a shroud plate on account of the neat effect of

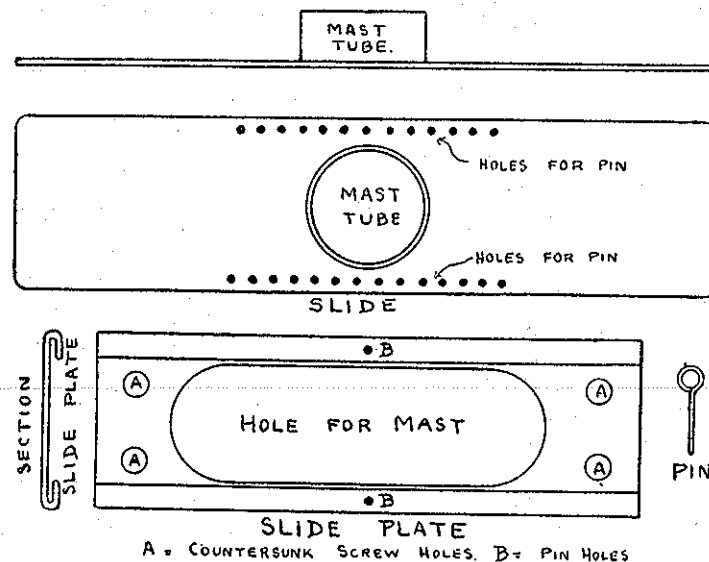


FIG. 82.—ADJUSTABLE MAST SLIDE, USED IN CONJUNCTION WITH MAST STEP ILLUSTRATED IN FIG. 80.

slide consists of a plate with a hole through it of a size to accommodate the mast tube, which is hard soldered into it. In order to fix the mast slide in any desired position, two holes are drilled right through the deck plate and

this fitting. Admittedly, it is not altogether good engineering practice to pull endwise on the screws which hold the eye in place, as everything depends on the thread cut by the screw in the wood. There is no shearing strain

on the screws, and therefore they need not be of large diameter, but they must be as long as possible, bearing in mind the depth of the shelf. Provided good screws are used, no trouble need be anticipated from their pulling out.

Another form of fitting used is more like the chainplates used on a real yacht, but it is not nearly so neat. This consists of a metal fitting, as shown in Fig. 83. It will be noticed that this has two straps down the side of the

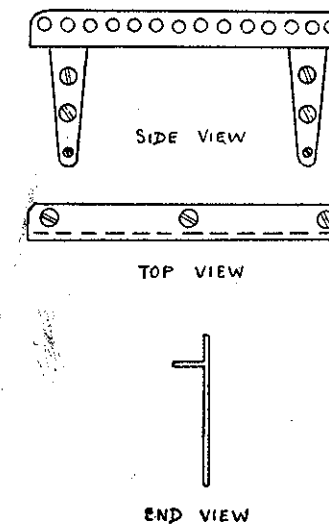


FIG. 83.—FORM OF CHAINPLATE (see Text).

yacht. This is really a stronger form of fitting, and the row of holes provide an additional advantage in that the shrouds can be adjusted according to the position and rake of the mast.

Rigging Screws.—Although these are not strictly speaking deck fittings, they can be considered as such as they hook into the gunwale eyes (or chain plates). Rigging screws (or turnbuckles) are used to tighten up the wire rigging that is used on large racing models. These fittings are made in three parts, as shown in Fig. 84. The upper and lower parts have a right and left-hand thread respectively, so that the wire is tightened by turning the body.

Jib Racks.—In order to permit the jib tack to be adjusted in accordance with the position

of the mast, it is customary to fit a jib rack on racing models. This consists of a rail of inverted T section (see Fig. 85). This is screwed to the deck and has a number of holes in it to hook the jib tack on to. It should have a sufficient length to not only permit the jib to be hooked out when the mast is in its furthest



FIG. 84.—RIGGING SCREW (OR TURNBUCKLE).

This is shown on larger scale than other fittings, being full-size for an A-class model.

position forward, but also to permit the smaller jibs to be hooked in towards the mast when sail is reduced in heavy weather.

Horses.—The horses are travellers on which the sheets run from side to side of the yacht. Their length is a matter of great importance, and affects the sit of the sails on the wind. A plain horse is shown in Fig. 86.

On racing models it is more usual to fit a horse with a jockey (see Fig. 87). The jockey

MODEL SAILING CRAFT

has three eyes on it for the sheet to be hooked into. If the sheet is hooked into the centre eye, it will be of equal length on the two tacks. By using the outer hooks, it is possible to arrange that the boat is harder sheeted on one tack than the other. This is a very great

the boat gets too far to leeward when she has her spinnaker set, the sheet can be instantly unhooked and the sail allowed to fly (see Fig. 89).

Bowsprit Fittings.—When the headsail is set on a bowsprit, the fittings used consist of a

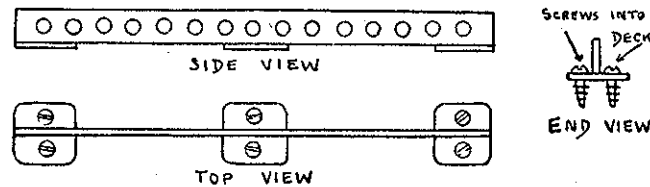


FIG. 85.—JIB RACK.

assistance in tacking. This is further explained in the chapter on Sailing. The traveller is fitted with two little wheels on the underside to make it slide easily across the horse, and if properly made and fitted, the sheet should never stick up at one side as occasionally happens with a plain horse. This might have

gammon iron (Fig. 90) on the stemhead and a heel plate (Fig. 91). If a bowsprit is used, the deck must be suitably strengthened in case of a collision.

SOLDERING AND SILVER SOLDERING

Whereas the building of a hull is woodwork,



FIG. 86.—ORDINARY FORM OF SHEET HORSE.

disastrous results if it occurred in an important race.

Suitable lengths for an A-class model are fore horse 8 in. and main horse 5 in.

Gunwale Eyes.—These are used for several purposes. They consist of a shaped plate with holes, as shown in Fig. 88. Gunwale



FIG. 87.—SHEET HORSE FITTED WITH JOCKEY.

eyes are made in this form primarily to prevent lines hooking up on them. The shrouds are frequently made fast to gunwale eyes, and they are also used to take spinnaker-boom hooks, spinnaker backhauls, and beating guy.

Spinnaker Sheet-hooks.—These consist of a plate with a hook, as illustrated, screwed to the deck. The advantage of these is that if

can easily purchase them. At the same time, there is a great deal of satisfaction to be gained from the knowledge that a model is entirely one's own production.

In making fittings, care should be taken to make them neat and yet strong enough for the work entailed, and for success in modern model racing good fittings, sails and gear are as essential as a good design and a well-built

SOFT SOLDERING

hull. It is usual to have fittings nickel-plated to protect them from climatic effects. In recent years, chromium-plating has come to the fore. This does not take the place of nickel-plating, however, but is an additional protection, as it is applied over the nickel deposit. It must not, however, be imagined that chromium is a complete protection and

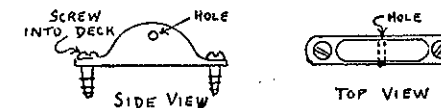


FIG. 88.—GUNWALE EYE.

that chromium-plated fittings do not require wiping down after use. The function of chromium-plating is to protect the nickel-plating and keep it bright. The protection of the article actually depends on the nickel coat which underlies the chromium.

Certain fittings, such as gunwale eyes, are beaten up into shape by means of a die, and the grooved pulleys used for the steering blocks are turned. Otherwise practically all the other fittings can be made with tinman's snips, hacksaw, pliers and files. All fittings should

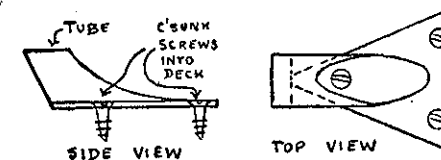


FIG. 90.—BOWSPRIT GAMMON IRON.

be hard soldered. Soft soldering is used to fix the brass washer on the rudder tube and for putting the eyes in wire rigging, as explained in the chapter on Rigging. It is, therefore, necessary for the builder to be able to soft-solder to a certain extent, and if he desires to make his fittings he will also require to be able to silver-solder.

There are a number of different grades of soft solder. The lowest is "plumber's solder," which is 2 parts of lead to 1 part of tin. This is not strong enough for model yacht work. The proper grade to use is "best blowpipe soft solder," which is 1 part

lead and 2 parts tin. This is actually the hardest of the soft solders, and it fuses at a temperature of 175° C.

The flux to use for this solder is zinc chloride (ordinary killed spirits), resin or ammonium chloride. There are also several patent compounds which are excellent. Killed spirits is nasty stuff, and though easy of



FIG. 89.—SPINNAKER SHEET-HOOK.

preparation, needs a certain amount of care in handling.

For soldering the washer on to the rudder tube a soldering iron will be found the most convenient. This should not be so big as to be clumsy or so small that it gets cold before the work is properly heated. Although called an iron, the soldering bit is of copper.

Before the bit can be used it must be tinned (coated with solder at the tip). The method of doing this is to heat the end to a dull red and rub the facets of the bit with an old file

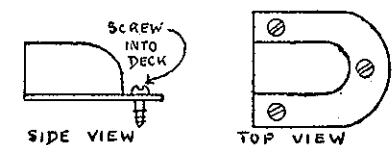


FIG. 91.—BOWSPRIT HEEL PLATE.

until the copper shows clean. It is then dipped into the flux and applied to the stick of solder. As soon as the solder is picked up, the nose of the iron is rubbed on a piece of tinfoil to spread the solder thinly and evenly on the tip of the bit. After it has been tinned, a bit must never be raised to a red heat or the tinning is destroyed. If this does happen, it must be cleaned off with a file and re-tinned.

All work to be soldered must be scrupulously clean and, above all, not greasy. Clean up bright with glass-paper or emery-cloth before starting. The flux is put on the

place to be jointed, and the iron is held in one hand and the stick of solder in the other. The stick with the bit touching it is then slowly drawn along the joint. This will cause a line of molten solder to run, and some care is needed to get just the right amount of solder without getting lumps or spreading it beyond the required part. Alternatively, drops of solder may be transferred to the work by means of the bit. When the iron is just the right heat and is well tinned, it will pick up solder in drops. When the work has enough solder on it, the bit must be worked up and down the joint to heat the work thoroughly and make the solder stick to the joint properly. At the same time the solder is spread evenly. If the soldering is done with an insufficiently heated bit, the result will be a series of lumps. If the bit is too hot, the solder becomes too fluid and runs too quickly. A certain amount of practice is necessary before a good job can be made.

In making the eyes in wires, sufficient solder is run on to the binding (see chapter on Rigging) with the iron. The end of the wire is then put into the gas flame and held there until the solder runs. When it does so, the solder is wiped round the binding with a piece of cloth sufficiently thick to prevent the fingers being burnt. This is on a small scale, equivalent to the plumber's method of wiping a joint, and a neat finish is obtained.

The iron can be heated in a red fire, but gas is recommended, as the iron will keep cleaner.

Silver soldering is infinitely stronger than soft soldering, and must be used for all fittings. If a joint is to be silver soldered, it is fatal to have previously soft soldered it. The slightest trace of soft solder will not only prevent the silver solder from running, but will actually cause the brass to melt the moment the work reaches a red heat.

There are several varieties of silver solder, and for model yacht fittings which are made of brass, one of 2 parts of brass to 1 part of silver will be found suitable. This is really a German silver solder, and is not so dear as silver solder proper. It is not quite so white as silver solder, but for this work that is not essential.

It fuses at a comparatively low temperature, but that is, of course, far higher than the melting point of soft solder.

The requisites for silver soldering are a suitable gas jet, a small mouth blowpipe, some sulphuric acid pickle in a jar, a small camel-hair brush, a piece of slate, a pricker and a piece of lump borax. The mouth blowpipe is not an expensive item, and can be obtained from almost any tool shop. The pickle is made by putting 1 part of common sulphuric acid into 20 parts of water. The piece of slate can be a bit of a broken roofing slate, but should be washed clean. The pricker is made from a piece of $\frac{1}{8}$ -in. wire by flattening the end.

The pickle is put into an old crock or jar. The first thing to do is to prepare the borax flux. The lump of borax is moistened with water and rubbed on the slate until a paste is formed. The work to be soldered is cleaned off properly and then heated somewhat and passed through the pickle. The silver solder is then cut into small squares about $\frac{1}{8}$ in., and each piece carefully coated with the flux on both sides. The parts of the work to be soldered are also carefully coated with flux. The work is best arranged on a piece of old firebrick. Care should be taken not to touch the work where the soldering is to take place with the fingers, as the grease in the skin will hinder the solder from running. The solder should not be touched with the fingers, and if it has, should be heated and put through the pickle. The squares of solder are now arranged round the joint. The small brush is convenient to put the squares of solder in position. As soon as all is ready the work should be slowly heated up, starting by blowing the gas on to the part of the job farthest from the joint. The borax will gradually dry out. Do not heat up too suddenly or the borax will bubble up and disarrange the solder. When all bubbling of the borax has ceased, the heat may be increased and brought gradually right on to the joint. Soon the solder will run. A little more heat should now be given to make the solder run properly into the crevices. When the work is nearly

cold, put it into the pickle and leave for about a quarter of an hour, when all the borax will be dissolved. The borax fuses at a much lower temperature than the solder, so do not be misled and take this for the fusing of the silver. The pricker may be found useful to

run the solder into any particular part of the joint should it prove obstinate. Plenty of flux should be used, and it is better for the novice to have a little too much solder rather than too little. The joint can finally be cleaned up with a small file and emery-cloth.

CHAPTER XVIII

Rigging, Standing and Running. Standing Rigging. Running Rigging. Rigging a Spinnaker. Kicking Straps. Beating Gys and Liverpool Boys.

ALL rigging can be divided into two main categories—Standing and Running. The standing rigging is comprised of the rigging which holds the mast and bowsprit in position, and the running rigging is that which hoists the sails and adjusts them.

The standing rigging of a racing sloop consists of the shrouds, topmast shrouds, jumper stay, and possibly a backstay.

The shrouds are the stays which support the mast on either side. As a racing sloop has its mast and topmast all in one (or, more nautically expressed, carries a pole mast), the shrouds that go to the masthead are known as the topmast shrouds.

The jumper stay is a small stay forward of the topmast and takes the pull of the head of the mainsail. The jenny, which is the strut that the jumper stay passes over, takes the forward strain of the jib halliards.

The backstay in a racing sloop is usually from the masthead to the counter outside the mainsail, and should more properly be known as a preventer backstay. The backstays proper in a real yacht come from the hounds of the lower mast to a point about half-way between the mast and the taffrail. There is one on each side set up on the gunwale. The leeward one is eased away each time, and the weather one set up so that they do not interfere with the sail.

Boats that have a bowsprit have a stay underneath it, known as the bobstay. In old-fashioned cutters with long bowsprits, stays were also fitted on each side of the bowsprit, known as bowsprit shrouds. In these craft a fore-topmast stay was carried as well, leading to the topmast head.

The forestay in a real yacht leads from the hounds to the stemhead and the staysail is hanked to it. In a model racing sloop the forestay is usually fitted down the luff of the

jib and is, therefore, dealt with under the running rigging.

The rigging of a racing sloop is shown in detail in the various diagrams that illustrate this chapter. The main and upper shrouds are made of rustless steel wire. It is usual to fit rigging screws (or turnbuckles) (see Fig. 84).

Some skippers prefer to use lanyards instead of turnbuckles, but this is not quite so neat, and also the cord which is used for the lanyards is prone to get wet and upset the careful adjustment of the standing rigging, which is essential to get the best results.

The ends of the wires have an eye. The method of inserting this in the end of the wire is to turn into the wire a white metal eye of a suitable size. The two parts of the wire are not spliced, but are served round with very fine copper binding wire. When this has been done, it is tinned well all over with the soldering iron. The whole eye is then put into the gas flame and heated until the solder runs. The joint is then nicely smoothed round with a cloth so that it is left nicely coated and sweated properly together.

The upper end of the shrouds should have a loop long enough to go over the mast, and their length should be nicely adjusted so that just sufficient turns can be taken on the turnbuckle, but still give a good range of adjustment to tighten as requisite.

For the hounds of a racing model, two round-headed plated screws are best. They are driven almost home, allowing sufficient between the head of the screw and the mast to form a shoulder for the wire. The two screws should not be inserted in the mast exactly opposite one another, as this tends to weaken the spar. If the builder has a passion for being exactly shipshape, the starboard shroud should be put on first, and the screw

STANDING RIGGING

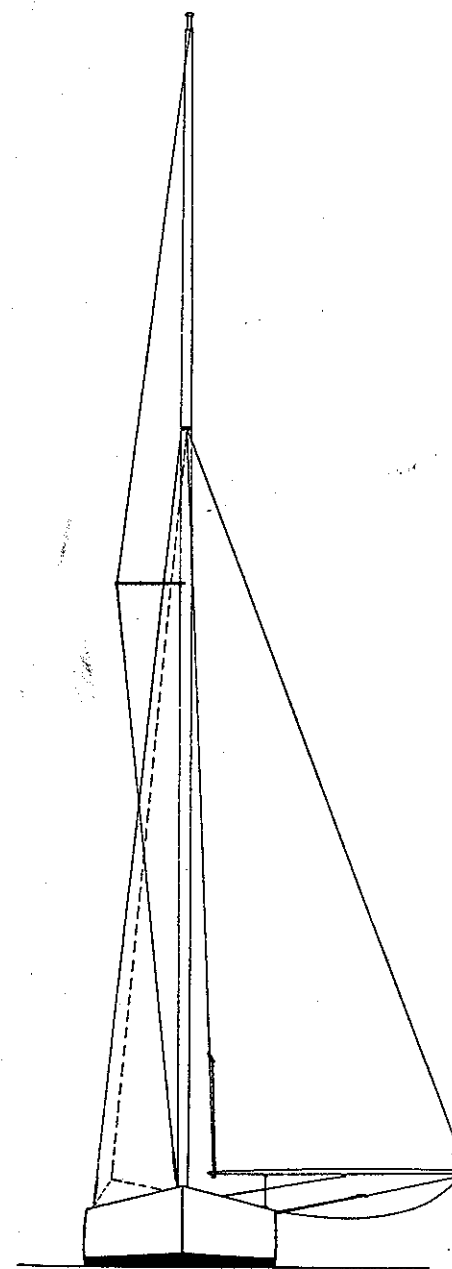


FIG. 92.—BOW VIEW OF MODEL YACHT.

On the starboard side are shown the lower shrouds and topmast shrouds. The spinnaker is shown to port, but the part to starboard, including the tack and sheet, is shown by a broken line. To avoid confusion the forestay has been omitted from this drawing.

for the port one can then be about $\frac{1}{8}$ in. higher. The screw for the starboard shroud will be on the port side of the mast and *vice versa*.

The upper or topmast shrouds start at the masthead, pass over the spreaders and finish on the mast at the level of the mastband. Two eyes to take them can be silver soldered into the mastband or two screw eyes put into the mast. In the latter event they can be put through two holes drilled in the mastband. This will prevent their pulling out and also help to hold the mastband securely in place.

The backstay can either be of light, yet strong, phosphor bronze wire or of thin, strong fishing line. This should be readily adjustable, and a bowser will be quite suitable if the fishing line is used. The ordinary bowser does not hold well on a backstay and a little wire bowser can be easily made (see Fig. 95).

The jenny stay can also be of either of these materials, but the phosphor bronze wire is preferable fitted with a suitable small turnbuckle.

It must be mentioned that the strain on the shrouds of a big model, such as an A-class, is very considerable, and the turnbuckles should be of sufficient size to stand the pull. As this is an endwise pull taken by the screw, it is essential that turnbuckles should be well made and have a well-cut thread. If the turnbuckles show any signs of easing back, lock-nuts can be fitted.

The standing rigging of a small yacht can be made of cord with bowser adjustment. One shroud a side is sufficient, and a jenny and other complications are unnecessary and simply provide extra windage aloft without answering any useful purpose.

The running rigging of a yacht consists of the halliards with which the sails are hoisted and the sheets which control the angles made by the booms. It should be carefully noted by the novice that a sail must never be spoken of as a "sheet." Sheets are ropes.

The halliards are differentiated by the functions they perform. Thus the jib halliard

MODEL SAILING CRAFT

hoists the jib and the main halliard hoists the mainsail.

In a real yacht the halliards must come right down to the deck, but in a racing model this would mean a lot of unnecessary cordage, and it is only necessary to make the halliards sufficiently long to enable the smallest suit of sails to be bent.

In a yacht with a gaff mainsail, the throat (or main) halliard controls the throat of the sail and the peak halliard hoists the peak.

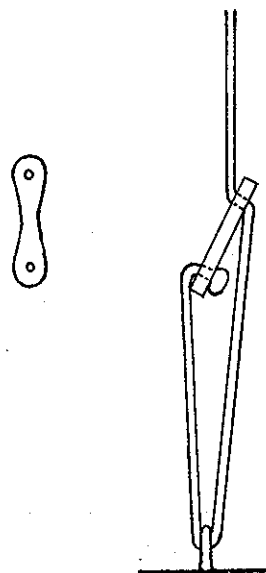


FIG. 93.—ORDINARY FORM OF BOWSER AND CORRECT METHOD OF REEVING.

The jib halliard is hooked into an eye in the mast. A special hook is used with a second eye to take the forestay. The forestay is rove through rings on the luff of the jib and is not continued to the deck, but only leads to the fore end of the jib-club. It passes through a special wire loop and adjusts with a bowser. The main halliard has a loop which hooks on to the headboard as shown (see Fig. 99).

A topping lift is the rope that takes the weight of the boom. It is not used in racing models.

For all rigging on a model yacht, the best quality line should be used. These lines are

obtainable from firms that specialise in model yachting supplies.

For the sheets, a jackline is fitted on the underside of the boom. This has an ordinary bowser to adjust the tightness and should always be kept taut to obviate the bowsers slipping. For the sheets themselves, ring bowsers are the best. With bowsers, there is a right and a wrong way to rig them. Bowsers depend not so much on their grip on the jackline as on the nip obtained from the twisting

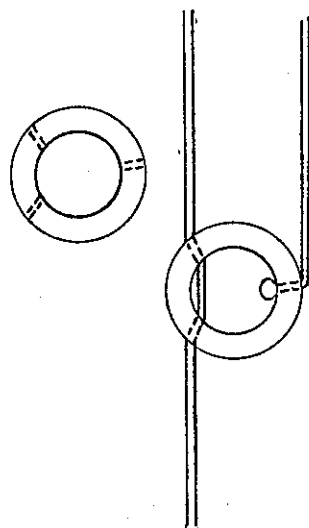


FIG. 94.—RING BOWSER AND CORRECT METHOD OF REEVING.

effect they have. Hence the methods of rigging illustrated give the best results (see Figs. 93 and 94).

The jib-sheet should be sufficiently long to enable the sail to be well eased out when off the wind. It has a bowser on a jackline for adjustment and leads through a screw eye in the after end of the club and thence to the traveller on the horse, where it has a hook.

The simplest method of rigging jib steering is with a bridle having a loop in the middle. The pulleys are screwed to the deck just aft of the jib horse as shown in Fig. 62. The gear is brought into operation by hooking on the sheet, which must be unhooked from the traveller. The jib steering lines as well as

RUNNING RIGGING

those on the main must be crossed, so that the line from the starboard block leads to the port end of the quadrant and *vice versa*.

The mainsheet proper (or beating sheet, as it is usually called, to distinguish it from the running lines) should be sufficiently long to permit the sail being eased off a point or two if required. It is not made long enough to let the sail right out, as that is unnecessary. When the sail has to be checked right out, the running lines are in operation and the beating

drawings, but even on such a small boat its use can be recommended.

Some skippers like all their sheets, including the running lines, to pull in forward. This is entirely a matter of individual taste, and will not make any great difference either way. The main disadvantage is that it means that the entire boom will have to be calibrated instead of only a part.

The bowser for the running lines can have a small ring bent into it to facilitate the attachment of the double lines.

It will be found convenient to fit hooks at each end of the jackline and others on the main boom for the sheets to run through. If this is done, the same jackline and gear can be used on all suits of sails.

The forestay of a racing model runs down the luff of the sail through rings (or hanks), and is adjusted by a bowser. The lower end goes through a ring on the end of the jib-boom ferrule.

The diagrams given will make the rigging clear.

As was explained in the previous chapter, different methods have to be used on a model in rigging a spinnaker to those employed on a real yacht. The difficulty is, of course, the absence of the human crew. Consequently, if the spinnaker was inclined to "sky," there would be nobody at hand to ease off the guy (or backhaul). The boom has a hook on it that engages an eye near the gunwale. This eye is set rather forward of the mast. The boom on the inner end is made nearly long enough to reach to the mast. The inner end has an uphaul of cord which can be adjusted with a bowser. This has its upper end hooked into a screw-eye in the mast, placed at a suitable height. The pull of the uphaul keeps the luff of the sail taut and the tack down. On the fore side of the boom is an elastic fore guy. This guy is often known by model yachtsmen as the "forehaul." The end of this guy has a hook which engages the last hole on the jib rack. Aft of the boom is an after guy (or backhaul). The angle of the boom can then be regulated by adjusting the backhaul, and the forehaul automatically takes

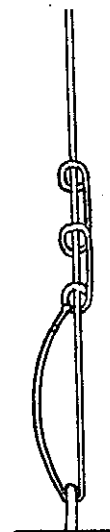


FIG. 95.—WIRE BOWSER FOR BACKSTAY, SHOWING METHOD OF REEVING.

sheet unhooked. It has a hook at the end for attachment to the traveller as required.

As the cord used for the jib sheet and beating sheet is liable to shrink when wet, and thus alter the sheet trims, many keen racing skippers use very fine rustless chain for their sheets.

The running lines should not be run on a bridle, but made double the full length. The reason of this is that if a bridle is used and the boom lifts, as it is very prone to do, the pull will immediately be distributed between the two lines instead of being concentrated on the weather one, and consequently the power of the sail to operate the helm may be entirely nullified. Figs. 96 and 97 show the Braine gear fitted up. For the sake of simplicity the tension slide has not been shown in these

MODEL SAILING CRAFT

up the slack. If required to run the boom forward in a hurry, the backhaul can be let

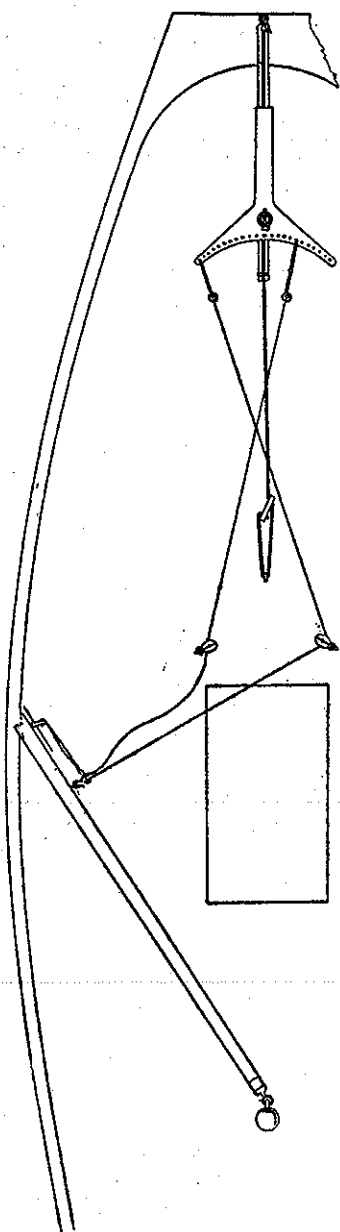


FIG. 96.—METHOD OF FITTING UP A BRAINE STEERING GEAR (see Text).

bowser is hooked over a deck-hook, as described in the previous chapter, under the heading of "Spinnaker Sheet Hooks." This enables the sheet to be let fly quickly in the event of a boat getting too far down to leeward. This is clearly shown in Fig. 92.

One useful little piece of rigging that is peculiar to models is the "kicking strap." When the main boom gybes, especially with the modern high Bermuda sail-plans, the sail is

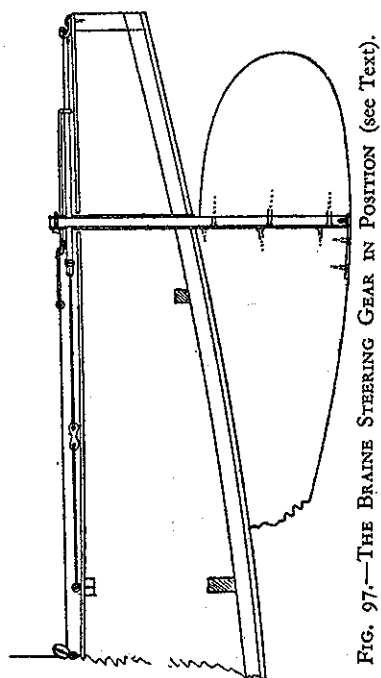


FIG. 97.—THE BRAINE STEERING GEAR IN POSITION (see Text).

apt to go foul of the spreaders or shrouds. In order to prevent the boom skying during a gybe, a kicking strap is fitted underneath the forward end of the boom. This consists of a cord under the boom fitted with bowser adjustment. The lower end is hooked to an eye in the mast just above the deck or to one in the after end of the mast slide. The other end goes to the underside of the boom. The point at which it is hooked to the boom should be about double the distance from the mast that the gooseneck is above the deck (see Fig. 100). Provided it is not kept too hard and always given a little play, the cord kicking strap will be found quite satisfactory. Some

go and the forehaul hauls the boom forward without further loss of time. The spinnaker sheet is adjustable with a bowser. The loop in the sheet formed by the end with the

KNOTS AND HITCHES

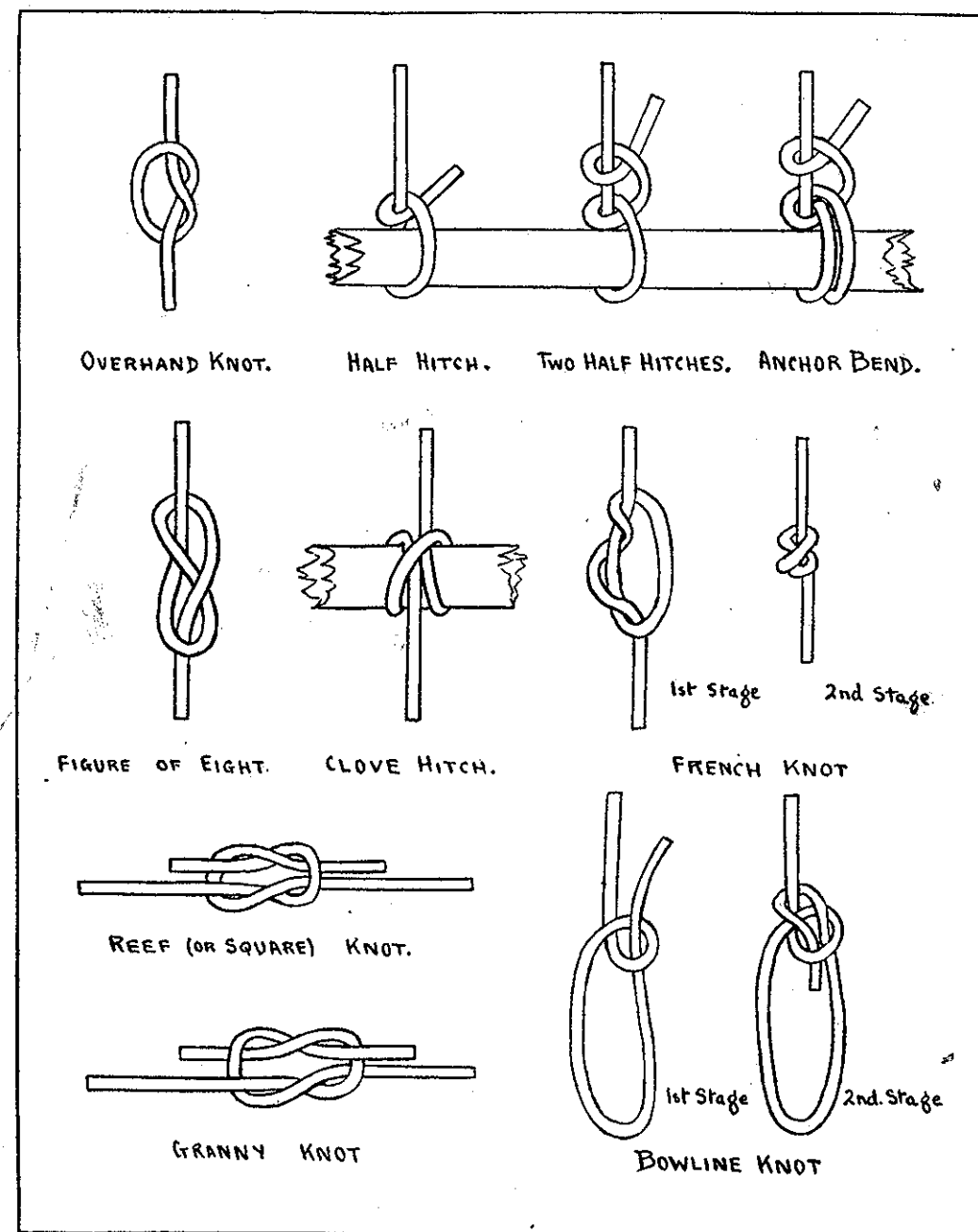


FIG. 98.—SOME KNOTS USEFUL TO MODEL BUILDERS.

N.B.—The "Granny" knot must never be tied in error for the Reef knot as it is liable to slip.

MODEL SAILING CRAFT

model yachtsmen prefer an elastic kicking strap with a cord adjustment. Whatever form is used, it should never be kept hard when the boat is on the wind, as it is apt to pull the boom down and may make the sail sit badly.

Two other pieces of rigging, the uses of which will be more fully explained under the chapter on Sailing, are the Beating Guy and the Liverpool Boy.

A model yacht has no skipper aboard, and so automatic means must be resorted to if it is desired to make her tack. The beating guy consists of a rubber spring with a cord tail and bowser adjustment. The most usual form is that which hooks on to the end of the main boom at one end and to a point on the gunwale about half-way between the mast and the end of the boom. The boat being put off with the guy on the windward side, stretches the guy out by reason of the wind pressure on the mainsail. Gradually the rubber edges the boom in and so hauls the sail closer and drives the boat up into the wind and so round, until she fills on the other tack. The strength of the guy and the amount of tension on it must be suited to the boat and the weather. In light weather, a less powerful guy is necessary. Too strong a guy will cause the boat to fling round before she has gained an offing. When boats are very stubborn on the guy (a frequent result of an ultra short base to a sail-plan), a pulley is sometimes put on the gunwale and a cord tail led to the quadrant to help the boat round. This is certainly efficacious for very short, quick tacking.

The guy shown in Fig. 101 is a rudder guy, but the ordinary plain guy is made in exactly the same way omitting the pulley on the gunwale and cord to quadrant. This form of rudder guy will serve as an ordinary guy when required by unhooking the line from the quadrant. The action is obvious. When the rubber stretches out, the pull comes on to the rudder line and operates the quadrant. The double adjustment enables the action to be regulated to a nicety.

Some boats have a trick of hanging for a long time head to wind, and are uncertain,

even when brought head to wind by the guy, as to which tack they will pay off on. To remedy this, a Liverpool Boy is fitted. This consists of a very light elastic with a cord adjustment arranged to haul the jib aweather, and it stretches out as soon as the sail fills (see Fig. 102).

Another difficulty in guying with very high, narrow sails when the wind is heavy, is that the boom lifts and the leach of the sail spills, and consequently the boat does not luff up. Some skippers have tried guys at the after end of the boom straight across the ship, but a guy half-way along the boom straight across the boat is probably more efficacious. This is sometimes used in conjunction with a stop on the guy, so that the boom is hauled exactly amidships and no more. Beyond this point the Liverpool Boy, which is used in conjunction with this method, ensures the boat coming round smartly on to the new tack. This subject is further discussed in the chapter on Sailing. Guys are, however, included in the present chapter in order to complete the running rigging of the racing model yacht.

There is no need for the model yachtsman to know more than a few of the commoner knots and hitches, but a few like to splice their rigging. In doing this, the easiest method is to use three or four needles (according to whether the cord is three or four stranded), and after unlaying the end, thread one strand through each needle and use these to make the tucks with.

The commonest knot is the overhand knot. The half hitch should be familiar to everyone. Sailors say "two half hitches will hold the devil." Another useful knot is the clove hitch. For a stop at the end of a line the figure-of-eight knot or the French knot can be used. The latter can be made to serve as a substitute for the stopper knot, wall-and-crown, or Matthew Walker. To join two lines, the best knot is the ordinary reef knot, but care must be taken to make a "square" knot, not a "granny," as the latter is certain to slip. For a loop the bowline knot should be used. With these few knots the modeller will be able to do anything required.

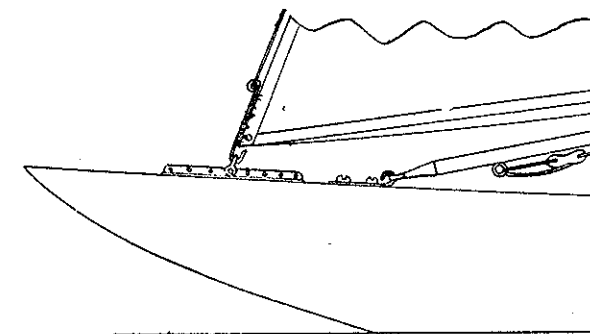
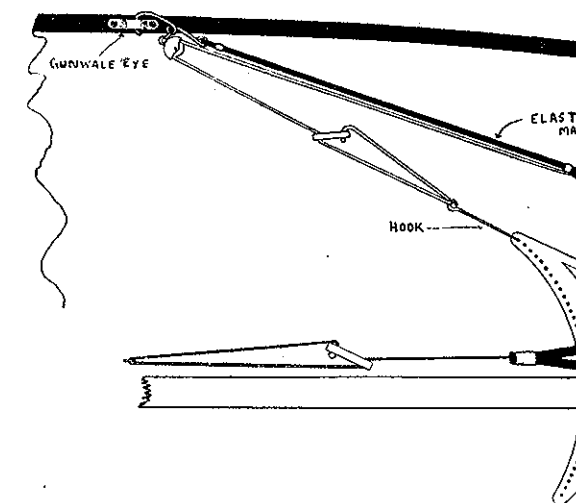


FIG. 100.—RIGGING AND FITTINGS FOR



The guy shown is a rudder guy, but an ordinary guy

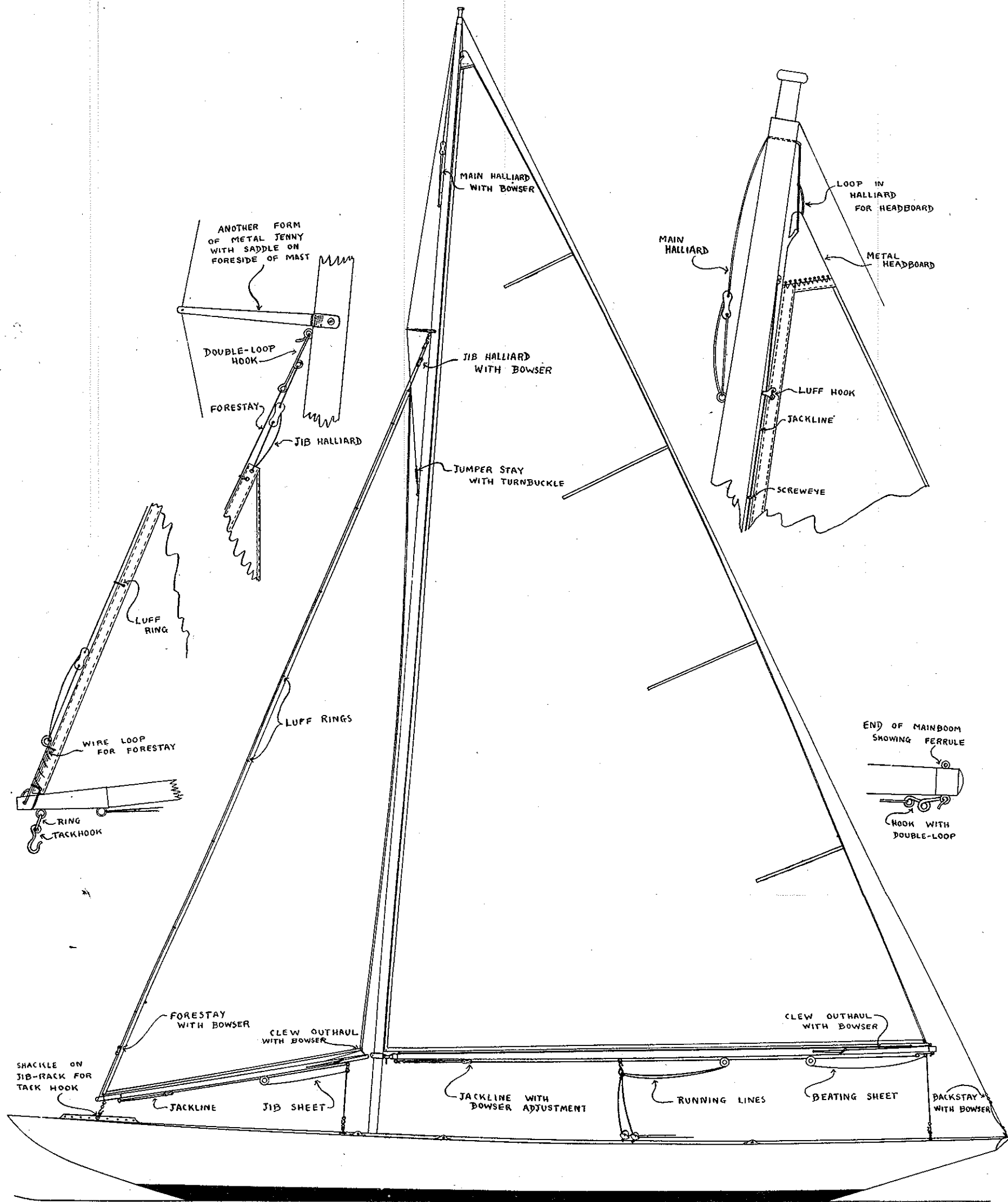


FIG. 99.—RIGGING DETAILS AND METHOD OF BENDING SAILS ON A RACING MODEL.

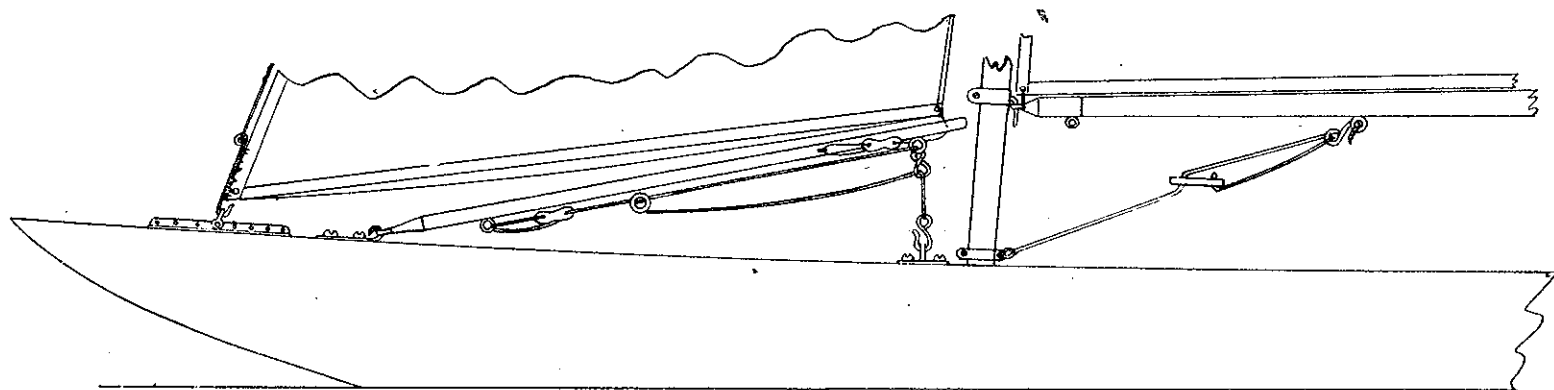


FIG. 100.—RIGGING AND FITTINGS FOR RADIAL JIB CLUB ARE SHOWN, ALSO KICKING STRAP FITTED ON THE MAIN BOOM.

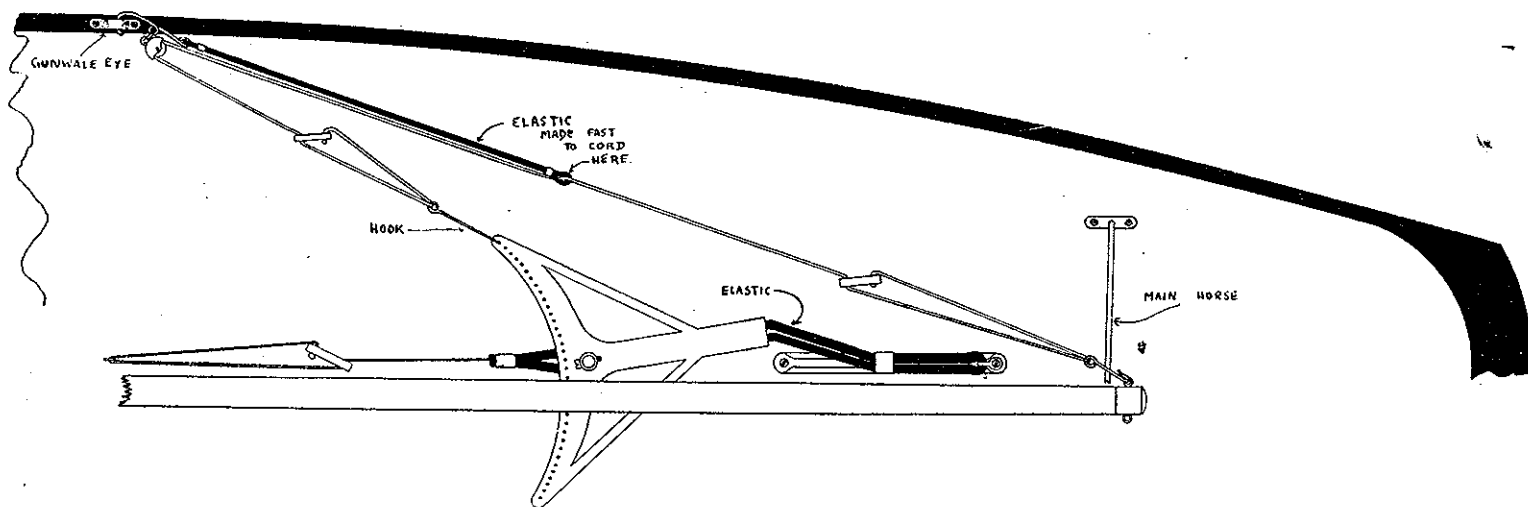


FIG. 101.—THE BEATING GUY.

The guy shown is a rudder guy, but an ordinary guy can be made in the same way, omitting the pulley on the gunwale and the line to the quadrant.

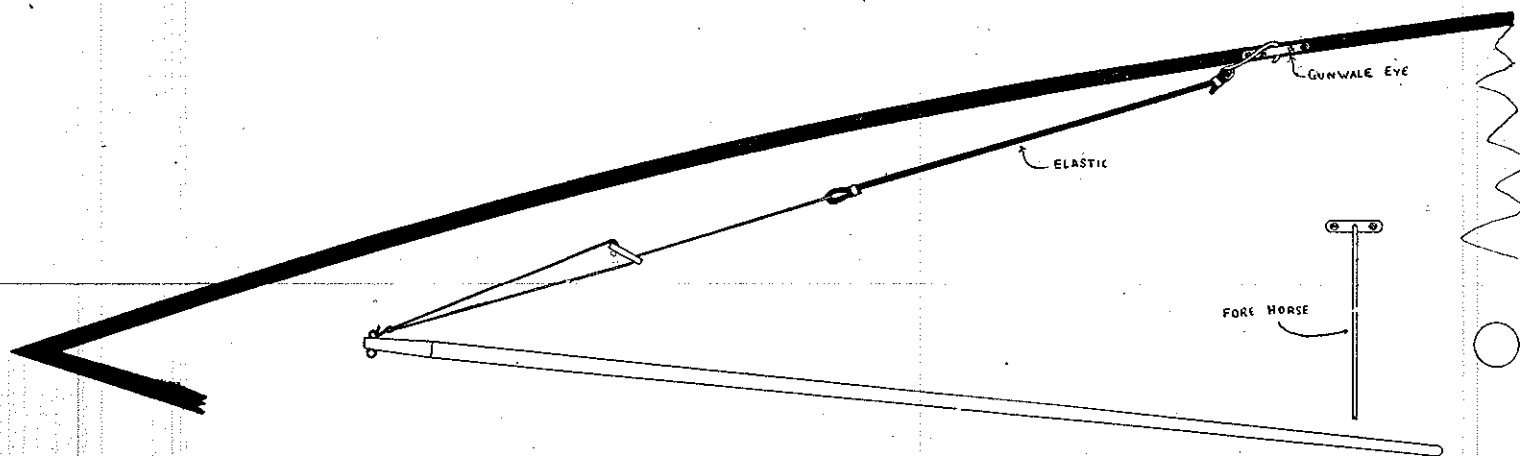
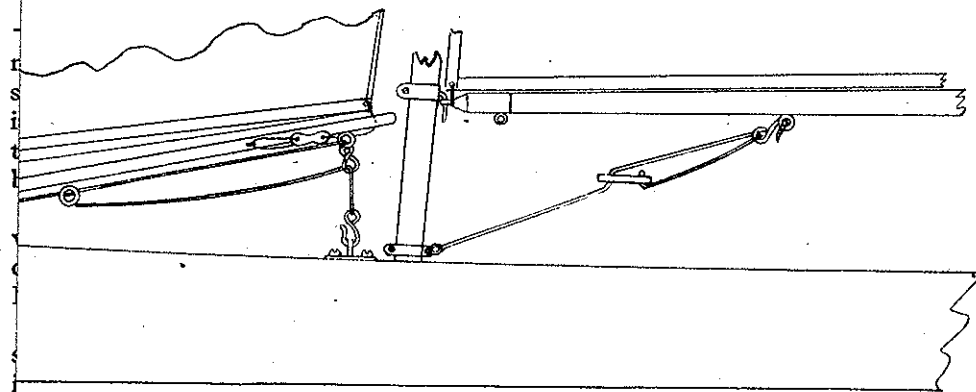


FIG. 102.—THE LIVERPOOL BOY.

Where it is desired to use a Liverpool Boy, the jib ferrule has two additional eyes, making four in all. The two side eyes are shown above.



RADIAL JIB CLUB ARE SHOWN, ALSO KICKING STRAP FITTED ON THE MAIN BOOM.

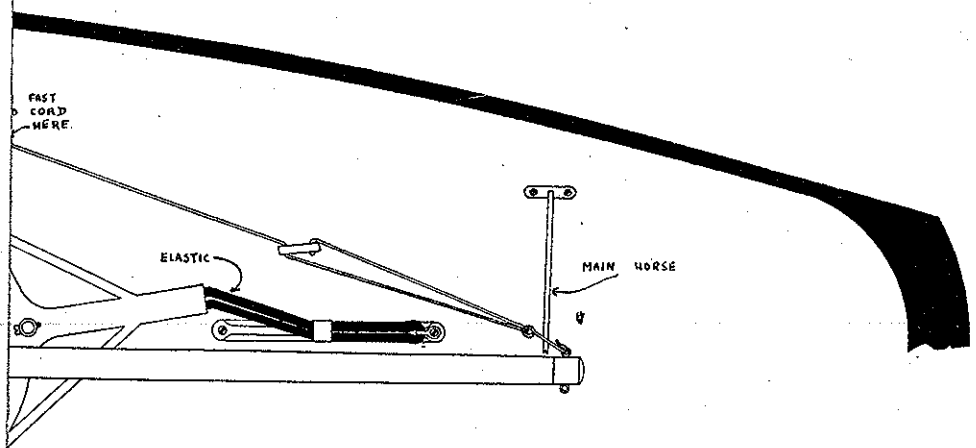
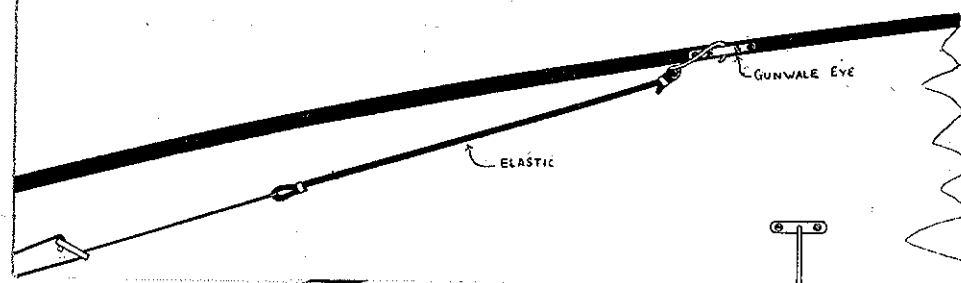


FIG. 101.—THE BEATING GUY.
can be made in the same way, omitting the pulley on the gunwale and the line to the quadrant.



CHAPTER XIX

Sails. Value of Good Sails. Effect of Flow in Sails. Cutting and Making Sails. Bending Sails. Stretching Sails. The Care of Sails.

WHEN the schooner *America* visited England and annexed the famous cup, which has ever since been known as the *America's Cup*, one contributory cause of her success was her sails. Whereas her British opponents had baggy sails of heavy flax cloth, the American yacht had sails of light cotton duck cut much flatter than those of her rivals. British yachtsmen were not slow to take the hint, and cotton sails came in and cut rapidly improved. The cult of the flat sail was, however, carried to extremes, and overdone until flatness became a fetish.

It must not be forgotten, however, that all these older yachts were rigged with gaff mainsails which were less efficient close-hauled than modern sailplans owing to the impossibility of keeping the gaff inboard. This is graphically shown in Figs. 103 and 104, where a gaff sail is shown in comparison with a triangular Bermudian mainsail. Obviously the Bermudian sail presents a very different problem to the gaff sail, and recent experimental work has proved that in order to get the best results a certain amount of flow is essential. This, however, must on no account be overdone, and above all the sail must be cut in the proper manner to ensure the correct curvature of the sail.

Undoubtedly, good sails are a most important asset to a sailing yacht, whether model or full-sized, and a good or bad sail will make all the difference between success and failure. It is, therefore, incumbent on those who seek for success in model yachting to have the best sails possible and take every care of them.

In recent years the study of aerofoils in wind tunnels has taught us many things about sails that we did not know before, and the result is increased efficiency. To state the same thing in other words, modern sail-plans give greater power for every square inch of

surface. The result of this is that a smaller surface will drive a bigger hull.

Now, the lessons that have been learned about sails are divisible into the three heads of Rig, Shape and Cut.

The Bermudian rig, which experience has taught us to be the best for racing yachts, took its name from a celebrated dinghy class in the Colony of Bermuda. These boats were rigged with leg-o'-mutton mainsails. The original Bermuda sail was, however, a very different thing from the present sail. The Bermuda dinghy sail was almost as long on the boom as it was in the hoist, and the sail was loose-footed with the tack hook below the boom—almost on the bottom of the boat, in fact. The boom projected forward of the mast, and had a heel tackle to strain it aft and flatten the foot of the sail.

Nowadays the term "Bermuda" (or "Bermudian") is applied to any rig that has a jib-headed (or triangular) mainsail. Thus we have the Bermuda Schooner, Bermuda Ketch, Bermuda Sloop, etc. The Bermuda sloop is what is adopted for modern racing yachts.

With regard to the headsails of the modern racer, it has been found that, except in the largest of real yachts, it is an advantage to use a single headsail, and consequently our racing model has her rig simplified to two sails—a Bermudian mainsail and a single headsail hanked on the forestay.

The subject of the rig and the shape of the sails, also the proportion of headsail to after-sail, has been fully discussed in the chapters on Designing, and therefore it is unnecessary to say more on the subject here. The third respects in which the modern sail is superior, viz., cut, however, falls directly within the scope of this chapter.

As it will be necessary to refer to the different parts of the sail, it will be best to define these.

The upper side of a gaff mainsail is the "head," the bottom side the "foot," the forward side the "luff," and the after side the "leach." The top corner is the "peak," the upper corner next the mast is the "throat," the lower corner next the mast is the "tack," and the after lower corner the "clew."

On a Bermudian sail the three sides are the foot, luff and leach, whilst the three corners are the head, tack and clew respectively. The sides and corners of a headsail are named similarly.

Now, the cut of the sail is all-important, as the method of cutting regulates the amount of flow (or draught) in the sail and the position of it.

The effect of flow in the sail is very marked. In light airs a boat with a fairly generous flow seems to pick up the wind far better than one with a very flat sail. Obviously, however, the harder the wind blows, the more draught (or flow) will come into the sail by reason of the bellying caused by the wind. Consequently, a sail that has a nice draught in light airs may have too much flow in a heavy wind. Too much flow is almost worse than none at all, as a boat with an over-baggy sail cannot be induced to point to windward properly. If the sail is over-draughted, either the boom must be too close-hauled on the wind or the upper half of the sail flaps—a choice of evils which will effectively prevent the skipper getting the best out of his craft.

With the modern high sail-plan, the mainsail only requires the slightest flow, and this should be so arranged that the leach of the sail is flat and the draught gradually comes to its greatest about one-third of the width of the sail from the luff, forming a parabolic curve as shown in the bird's-eye view in Fig. 104.

Racing models have several suits of sails, and the smaller suits which are used in harder winds can be cut flatter than

the first suit. The smallest storm suit can be cut practically dead flat, as the wind will provide all the draught that is needed. In cutting any sail, it must not be forgotten that

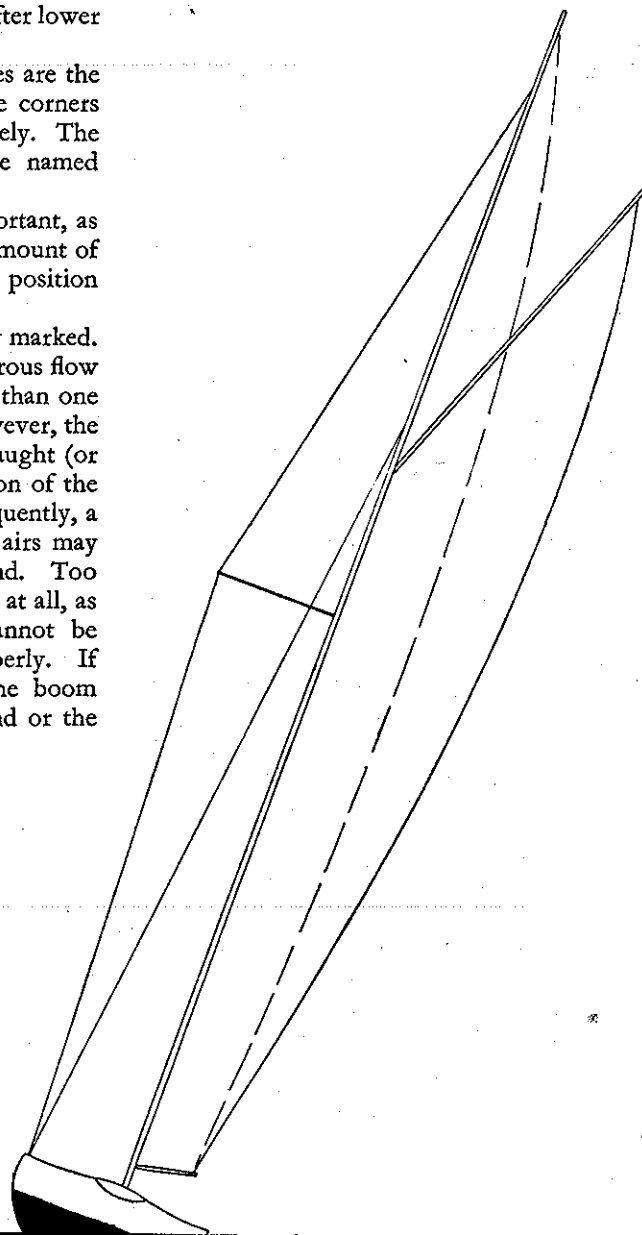


FIG. 103.—GAFF SAIL AND BERMUDIAN CONTRASTED TO SHOW GREATER EFFICIENCY OF THE LATTER WHEN CLOSE-HAULED.

the cloth stretches to a certain extent, and the final shape of the sail is only attained after it has been used a few times.

In a real yacht, the sails have to be made in a different manner to that adopted for models, and consequently sail-stretching is a much more serious business on the prototype. At the same time, a model's sails require care in use and have to be stretched properly if they are to prove thoroughly satisfactory.

The method of making a model's sails is to run a narrow hem up the leach and bind the other edges with linen tape. The cloth used for model racing yachts is Union Silk, which is mainly the finest Egyptian yarn cotton. The tape used for binding is the finest quality linen tape. The width of this varies with the size of the sails, but $\frac{1}{8}$ in. is suitable for an A-class model.

The first step is to mark out the cloth and cut it. The cloth should be pinned flat, *without stretching*, on to a smooth surface. A drawing-board, or even the kitchen linoleum, will answer the purpose admirably.

The leach of the sail will have to be cut on the selvedge of the cloth, as the warp must lie parallel with the leach. Mark out the leach accordingly, setting it inside the selvedge sufficiently to allow for the outward bow and the hem. This hem should be as narrow as possible (about $\frac{1}{8}$ in.), and if the sewing machine used is fitted with a narrow hemmer, this should be employed for the purpose.

Two lines are accordingly drawn for the leach of the sail—one where the leach actually comes and the other where the sailcloth is to be cut. With practice, the second of these lines may prove to be superfluous, but the novice will be well advised to put the two. The leach is laid off exactly in accordance with the plan with the correct roach. The term "Roach" is used to imply the outward bow

given to the leach of a sail. It may be mentioned that if a sail is cut absolutely straight on the leach, it will soon drop in and become hollow.

The amount of flow in a sail is determined by the way in which the foot and luff are cut, and only experience will teach how much draught will result from any particular method of cutting them. If a very big draught is required, the foot and luff can be cut with a fair amount of outward bow. A lesser amount of bow will produce a flatter sail, and if they are cut dead straight a flat sail will result.

The novice is advised to cut his sail with just a slight flow. On an A-class model this would mean that the luff of the mainsail should be cut very slightly convex and about $\frac{1}{4}$ in. outward bow will be sufficient on a luff measuring about 79 in. The foot of the sail has also to be cut slightly convex and about $\frac{1}{4}$ in. outward bow will be suitable on a foot measuring about 36 in.

The curves of both luff and foot should be parabolic in character with their greatest part one-third of the length of the side from the tack.

The foot and luff are marked accordingly, and as these sides are being bound with tape, the cloth is cut exactly to size without any allowance for hemming.

The head of the sail is hemmed across in the same manner as the leach, but with a wider hem, the cloth being triple folded and the headboard sewn on to it in due course. The headboard is best made of aluminium of a suitable thickness, say about 16 gauge. This can be seen clearly in Fig. 99.

When the sail is marked out, it is cut out with a sharp knife or an old razor-blade in a suitable holder. The hem must then be put up the leach and across the head. Silk should be used for sewing the sail as cotton is affected

by damp and shrinks. Before starting to sew, the machine should be adjusted so that the silk is just tight enough, but not sufficiently tight to pull the work. As

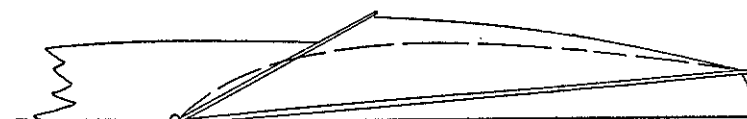


FIG. 104.—BIRD'S-EYE VIEW OF SAILS ILLUSTRATED IN FIG. 121.

mentioned, the narrow hemmer should be used for the leach and head of the sail.

The foot and luff of the sail have now to be bound. Crease the tape sharply down the centre, carefully folding it to get this exact. Fold the raw end of the tape inside about $\frac{1}{4}$ in. and tack the clew of the sail lightly inside the binding. The other end of the tape is pinned firmly down to the table. The tacked corner of the sail is then taken in one hand, and the binding pulled until it is taut, but not unduly stretched. The cloth is now laid into the binding with the other hand, care being taken not to stretch it in the least. This is very important, as otherwise the sail will be pulled out of shape. Care should be taken to get the cloth right into the fold of the binding. The cloth can now be pinned into position in the binding, and a line of stitching run along the inside edge of the tape. The tape is then put along the luff in a similar manner. When the edges are bound, a second line of stitching is run around the extreme outside edge of the binding to take the creases out.

Batten pockets have to be put on to the mainsail, and for this purpose $\frac{1}{2}$ -in. linen tape can be used. The extreme end of the pocket on the leach is left open to insert the battens and closed afterwards with a few stitches. Some makers leave about an inch of the upper seam open and sew the end of the pocket up permanently so as to permit the battens to be replaced easily and quickly without sewing. The headboard is now sewn on to the sail.

Eyelets have to be put into the corners to take the outhauls and lacing. For this purpose very small white metal eyelets are used. The holes in the sail for these are best made with a pointed spike. The fibres of the tape should not be cut out with a punch, as it weakens the fabric. The eyelets are inserted and spread out. This can be done with a proper eyelet punch, or, if the builder has not got one of these implements, any suitably shaped tool can be used.

Before proceeding any further, it is necessary to decide what method of attaching the sails to the spars is to be employed. The old-

fashioned method was to use a lacing, and some skippers still prefer this system. If the sail is being laced, eyelets will have to be let into the foot and luff of the mainsail at suitable intervals. On an A-class model 3 in. apart on the boom and 4 in. down the luff will suffice.

In lacing a mainsail the correct method is to use a continuous lacing for the foot and half hitch it at each eyelet. In a model, however, this may be inclined to pull the sail unduly, and possibly it is better to use a continuous spiral lacing. The luff is laced to the mast with a continuous spiral lacing.

The more modern method of bending sails, particularly Bermuda ones, is to have hooks along the sail and wire jackstays on the spars. This makes the sail very easy to bend or unbend quickly. The wire jackstay is made by first forming a loop in one end in a manner similar to that described for making the eyes in wire shrouds. Small screw eyes are then placed along the mast and boom at intervals, arranged to come between the hooks on the sail itself. The jackstay is rove through these and a loop made in the other end. The bottom of the jackstay should be about 2 in. above the gooseneck and the top about 2 in. below the limit of hoist of the sail. The bottom end of the jackstay is attached to the mast with a small round-headed screw $\frac{1}{4}$ in. long. The spar is then bent slightly, and the wire stretched out and the top end screwed to it. On letting the spar straighten out the jackstay should be found to be pulled reasonably taut. Hooks have now to be sewn along the sail at the intervals mentioned above, but spaced to fall midway between the screweyes. The best thing to use for the purpose are white metal hooks of the hook-and-eye variety used by ladies for dresses. These are sewn on to each side of the sail alternatively. The hooks should be placed so that the sail comes right into the bend and the tip of the hook is on the opposite side to the base.

Before proceeding to make the jib, it might be as well to consider the exact nature and function of the headsails. The most obvious effect of the headsail is that it keeps the boat's head from coming up into the wind. Now, on the

wind a jib must not be too baggy, as otherwise it will be impossible to bring the yacht really close to the wind, as the headsail will flap or only draw partially. Apart from the question of balance, nothing stops a boat's way more than a sail which is not asleep. (N.B.—A sail is said to be asleep when it is drawing properly and not flapping about.)

On the other hand, the headsail should primarily be a lifting sail. A flat jib will not help a yacht's progress, but it will tend to force her head down in the water instead. Immediately the jib tries to force a boat's head down, the buoyancy of the bow will combat this and the boat will gripe.

An actual experience on a real yacht in heavy weather confirms this fully. It was blowing very hard and the mainsail was double reefed. As the boat had been griping very hard, the full headsail was left, and in spite of this, she griped harder than ever and became almost unmanageable. A further reef in the mainsail did not improve matters at all. The owner was then persuaded by a friend to greatly reduce the headsail. Immediately the boat, which had been labouring heavily, became easier, and the gripe vanished altogether. Headsails have an extraordinarily pressing effect, and a reduction of headsail helps a boat immensely.

From the above, it will be seen that a jib should not be an absolutely flat sail laced hard down to a boom and without any life or flow, but should have just a nice moderate draught.

The leach of the jib can be cut with a slight roach. If battens are used, care must be taken that they do not make the sail too flat, as this impairs its pulling power. The leach is cut parallel with the selvedge of the cloth and hemmed in a similar manner to the mainsail. The foot of the sail is not laced all along to the boom (or club), but is attached at the tack and clew only. Owing to the fact that the jib on a model must be self-acting upon a horse, it is necessary to use a jib-club. An alternative kind of jib-club to the ordinary one is the "radial-boom," which was described in a previous chapter (see Fig. 100).

If the foot of a jib attached to a boom were

cut straight across, and the sail was not laced on the foot, the sail would rise in the middle and make a hollow foot with a very ugly gap between the spar and the sail. The foot is, therefore, cut with a very generous roach. The edge of the roach can be hemmed with a small hem like the leach. It is obvious, however, that if the sail was left like this, the roach would soon pull out straight and the sail go all shapes. A line of tape is accordingly machined straight across the jib from tack to clew to take the pull along the foot and keep the sail in its proper shape. The luff of the jib should be cut absolutely straight, but if the sail is inclined to be too baggy it can be hollowed very slightly. The luff is taped in a manner similar to that described for the mainsail (see Figs. 99 and 100).

Eyelets must now be put into the corners of the sail and rings or hanks up the luff. These can be at about 4-in. intervals. For this purpose proper rings of white metal are obtainable. If these are not available, the hooks left over from the packet of hooks and eyes can be used.

Many designers give the dimensions of the second and third suits of sails on their sail-plans, but if these are not given, a rough-and-ready method of arriving at these is to reduce each dimension by 10 per cent. for the second suit and 20 per cent. for the third suit. With the modern high Bermuda plans, it may be found that the reduction so obtained is not enough for the jib in proportion to the mainsail. Actually speaking, it is best to work out the centre of effort of the three plans and arrange them so that they are the same.

The spinnaker should be of lighter cloth than the working sails, and silk of a suitable weight makes a very good sail. The spinnaker is essentially a bellying sail and should be cut with as much draught as possible. The measurements taken for rating purposes are the hoist and the distance from the tack to the mast. The tack should be kept fairly high, so that the sail will not dip into the water if the yacht rolls as she runs. The foot of the sail should be made sufficiently long to come well past the mast, and should be cut with a

generous bow. The luff of the sail is taped in the manner described, and the foot has a narrow hem, but no tape across from tack to clew as the jib has. The after-leach of the sail can be formed by the actual selvage of the cloth. Eyelets are put into the corners of the sail, and a hook should be put into the head to hook into the screw-eye on the mast. The adjustment is made on the boom uphaul as described in Chapter XVIII. The tack of the sail is made fast with a lanyard to the spinnaker boom.

The method of bending the mainsail is first to make the tack fast to the gooseneck on the boom. If a boom ferrule is not being used, the boom must have a hole drilled in it for the clew outhaul. This is bent on to the sail, passed through the eye on the ferrule, and a screw eye is provided in the side of the boom. A small bowser on the outhaul gives the necessary adjustment, so that the clew can be hauled out as required. The sail is then hooked on to the jackstay along the boom. The head of the sail is then hoisted and the sail hooked to the jackstay on the mast. On big, heavy models, such as an A-class, it is not a bad plan to use fine copper wire instead of cord for the tack lanyard. The strain on this lanyard is considerable, and the wire frays through less readily than the cord. It is by no means unusual to have a tack hook fitted to the gooseneck, as shown in the drawing of a gooseneck in the chapter on Fittings. Whether a lanyard or hook is used is not a matter of any moment provided the tack of the sail is made fast close into the angle formed by the mast and boom. The reason of this is so that there is a straight pull on the luff and foot of the sail. Without this it is obvious that the sail will be stretched out of shape. If the gooseneck does not come in sufficiently close to the mast, this can be easily arranged by using a cranked hook bent into the correct position.

The jib is first bent to the club. The tack

is made fast to this with a cord or wire lanyard, and a clew outhaul fitted in a similar way to the mainsail. The plan a few years ago was to make the fore stay and jib halliard all in one, but this is not at all advisable, as it means that unnecessary pull is thus put upon the luff of the sail. The fore stay is rove through the hanks on the luff of the jib, and has an adjustment with a bowser at the lower end, which leads to the forward end of the jib-club. The top end has a hook which goes into the screw-eye on the mast for the jib halliard. The halliard is fitted with a bowser and can be passed through the same hook as the fore stay.

* * * *

A good suit of sails can soon be spoiled, and therefore a few words on the care of sails will not be out of place. When a new suit of sails has been bent, it is best, if possible, to give them their first outing in a moderate breeze and strong sunshine. The outhauls and halliards should not be hauled out too hard. As the sail stretches, the slack can be gradually taken up. After about three outings the suit should have gently come to its final shape, and the halliards and outhauls can be set up harder. They should, however, never be so taut as to pull the sail out of shape and strain it.

When the boat is put away after sailing, the sail outhauls and halliards should be eased up generously. Sails must never be rolled up closely when wet. If the sails get wet, the first opportunity must be taken to hang them up to dry. If salt water gets on to the sails, or dirty water from the pond, they should be rinsed out with fresh water before being hung up to dry when the boat is put away after sailing.

If due care is taken of sails, their effective life will be doubled and more satisfactory service obtained. The little extra trouble entailed is, therefore, amply repaid in satisfaction.

CHAPTER XX

Getting Ready to Sail. The Different Points of Sailing. The Theoretical Angle for Trimming the Sails. Beating to Windward. The Beating Guy, its Theory and Use. The Rudder Guy and its Use. The Liverpool Boy and its Use. Reaching. Jib Steering on a Close Reach. Running and the Use of the Braine Gear. Retrimming. Mast Position and Tuning-up. Using the Vane Gear.

THE first thing on arrival at the pondside is to rig up the yacht. For a first trial the mast should be placed exactly in the designed position and rake. The shrouds should be carefully set up, care being taken that the mast is not pulled over to one side. The shrouds should be moderately tight, and in very light weather some yachts like them eased off a trifle. The backstay should also be adjusted and the jumper stay, if fitted. The sails are now set and the sheets hooked on. The forestay should be set up sufficiently hard to prevent the luff of the jib sagging.

Before hoisting sail, the skipper will, of course, determine which suit he is going to use according to the weight of the wind. It is always better to be slightly under-canvased than over-canvased. An over-canvased yacht is always wild and hard to control.

Before trimming the boat, carefully look over everything and see that nothing has been forgotten. It is now necessary to decide the trim. According to the trim of the sails, her course will vary. The direction of the wind and its relation to the desired course should therefore be carefully noted.

There are 360 degrees in the full circle of the compass, but the sailor divides these into thirty-two points. The four cardinal points are North, East, South and West. North to East is divided into eight points. It is advisable to remember this, as one frequently speaks of so many points off the wind, etc., and each point is $11\frac{1}{4}$ degrees. Four points off the wind is at an angle of 45 degrees to the wind. When the wind is dead abeam, the yacht's course is eight points off the wind, or at right angles to it.

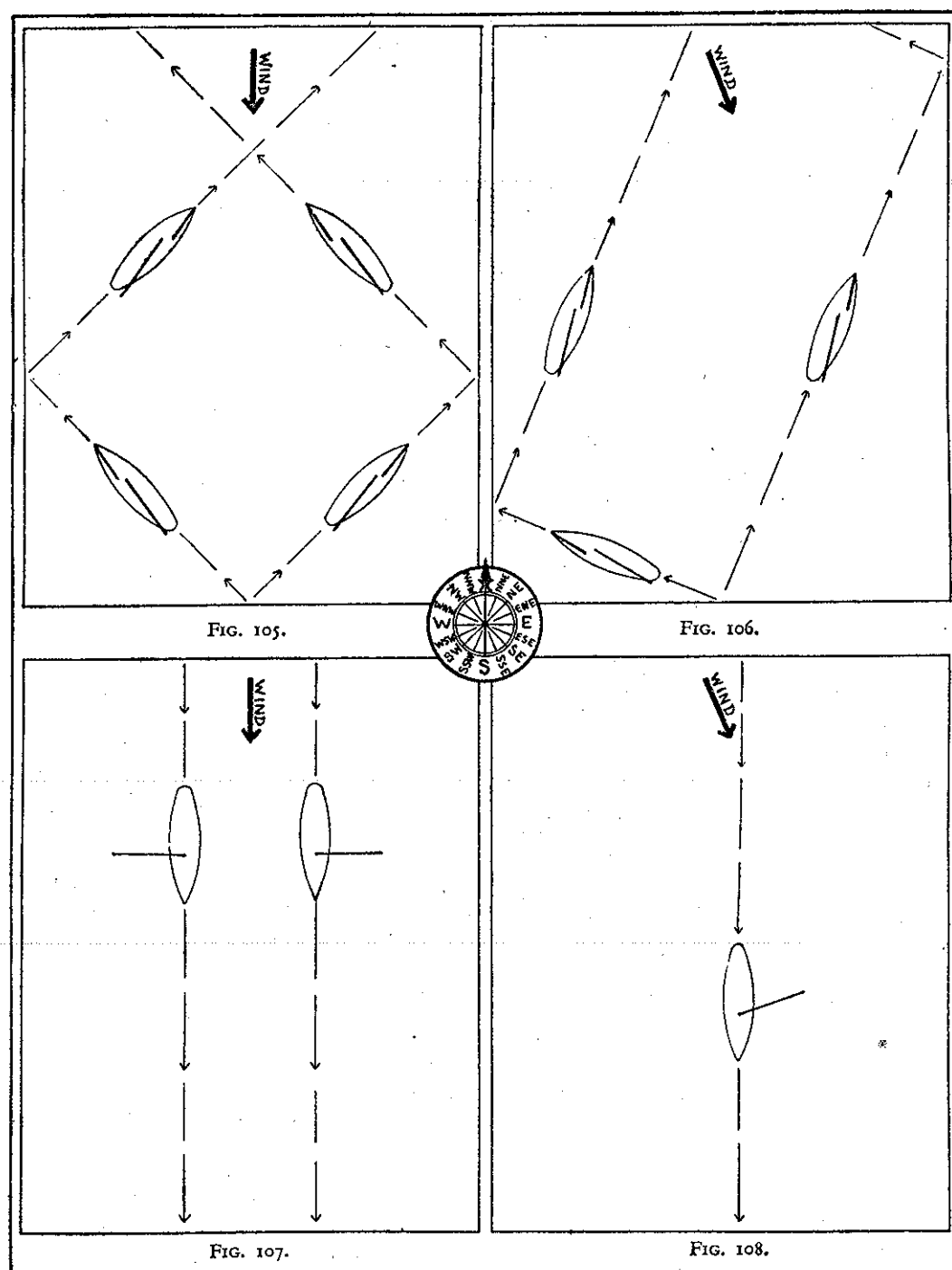
No vessel can sail dead against the wind, but a smart yacht can sail at about four points off

the wind. To work dead to windward a zigzag is accordingly made, and this is known as tacking to windward. The yacht first makes a tack to one side of her course and then one to the other side until the objective is reached. Each tack is often spoken of as a "leg."

When the wind is not absolutely dead ahead but sufficiently so to necessitate tacking, it will be found that sailing four points off the wind, one leg will be nearer the course than the other, and more progress made. Thus, for instance, if the course is North and the wind N.N.W., when the yacht is going to the right she will be making closer to her course than when going to the left. Going to the right at four points from the wind, she will be steering N.N.E. Going to the left, she will be steering W.N.W. When she is going to the right of her course, she will have the wind on her left (or port) side, and this is known as the port tack. The sails of a yacht on the port tack will be out to starboard as the wind is to port. Similarly, the starboard leg is when she is going to the left with the wind on her right (or starboard) side, and the sails out to port. It will be seen that under these conditions the port tack is the long leg and the starboard tack the short leg.

The above may sound somewhat confusing to the novice, but a glance at the diagrams will make the matter perfectly plain. These should be thoroughly digested, as they are very important and will make the explanations about sailing to windward much clearer. In these diagrams it is assumed that the yacht will sail close-hauled four points off the wind.

As will be seen from the diagrams, the pond lies North and South. The pond depicted is not an ideal shape by any means, as it is too short in proportion to the breadth. Ideal



proportions are 4 to 1 or 5 to 1. The proportions of the pond shown were, however, governed by the size of page at our disposal.

In Fig. 105 the course is from South to North, and as the wind is North, it is an absolute beat to windward, and both tacks being equal it does not matter which tack we start on. The boat going to the left has her sails on the port (left) side and the wind on her starboard (right) side, and is, therefore, on the starboard tack. The boat going to starboard with her sails to starboard has the wind to port, and is, therefore, on the port tack.

In Fig. 106 the course is still from South to North, but the wind is N.N.W., and therefore two points off a dead beat. From the diagram it is obvious that the port tack takes the boat nearer to her course than the starboard one. Put absolutely nautically, on the port tack the boat can lay two points from her course whilst she is six points off on the starboard tack. Thus the port tack is the long leg and the starboard tack the short leg. It almost invariably pays to start on the long leg.

In Fig. 109 the course is again from South to North and the wind N.W. As this is four points off the course which has to be made good, the boat should just be able to lay her course with the wind four points on the port bow. It will be noticed that the course steered is a little to windward of the centre of the lake. This allows for the possibility of the wind heading the yacht.

With the wind anywhere from North to N.W. in sailing from South to North the yacht will be as close-hauled as she can advantageously sail. In other words, she will be in her windward (or weather) trim.

In Fig. 110 the wind is W.N.W. and dealing with the yacht sailing from South to North, she has the wind two points ahead of the beam and is, therefore, not so close-hauled as when the wind was more ahead. She also is steering a little to windward of her course in case the wind hauls more ahead. This course is called a close reach.

In Fig. 112 the wind is West, so both the yacht going from South to North and the one

returning from North to South have a beam wind. Their trims are accordingly identical except that the former has the wind to port and the latter the wind to starboard. Both boats are said to be reaching.

Returning to Fig. 110, where the wind is W.N.W., and dealing with the boat coming from North to South, she has the wind two points abaft the beam, giving a free reach, and this wind would be spoken of as a free wind.

In Fig. 111 the course is from North to South and the wind N.W., and therefore four points abaft the beam. This is a very free reach, almost a run, and the boat could probably carry a spinnaker well forward. Unless the wind was very steady, however, it would probably be wiser not to do so in case the wind hauled round more abeam.

In Fig. 108 the wind is N.N.W. as in Fig. 106, but this time the boat has to return from the North end of the pond to her starting place at the South end. The wind is six points abaft the beam (or only two points off being dead astern), and is said to be on the starboard quarter. The mainsail is checked right out and the spinnaker set slightly forward.

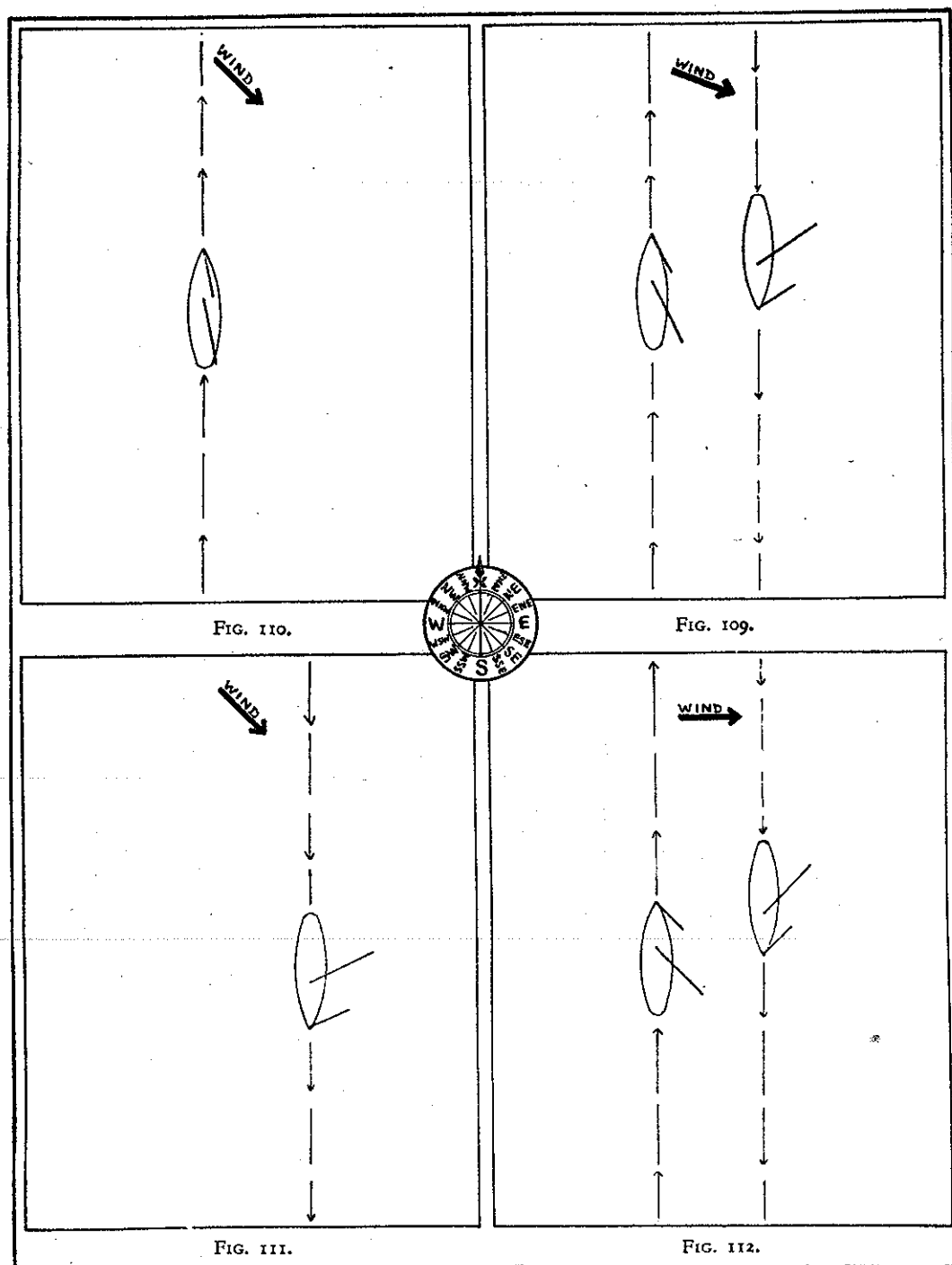
In Fig. 107 the wind is due North, as in Fig. 105, and the boat is returning from North to South. As the wind is dead astern, it does not matter whether the mainboom is carried to port or to starboard, but if the wind shows the least sign of veering* or backing,† the mainboom should be carried on the opposite side to avoid any risk of getting by the lee. The mainboom is eased right off and the spinnaker hauled round to a position within 10 degrees of abeam.

In these diagrams every point of sailing has been dealt with from a "dead nose-ender" to a "dead run," and the approximate sail trims illustrated. It will, however, be as well to amplify these remarks somewhat to enable the novice to get the best out of his model.

How close to the wind a yacht will point

* Wind "veering" = shifting round in a clockwise direction.

† Wind "backing" = shifting round in an anti-clockwise direction.



depends very much on the type and rig. It is, however, no use to expect a barge yacht to perform in the same way as a racer. Only a very close-winded modern yacht will get as near the wind as four points, and it is no use trying to pinch a yacht more than she will stand. As a yacht is closer hauled, she begins to lose speed through the water until she loses way, and comes head to wind altogether. When a yacht is head to wind, her sails flap and do not draw. If a yacht gets into the position of head to wind and remains so, this is known as "being in irons." A vessel in irons will flap helplessly and probably drift astern. What the skipper has to find out about his yacht is just how much he can make his boat point before her speed drops too low to be effective. A further point that has to be remembered is that a yacht's lateral resistance depends to a large extent on her speed through the water. A yacht that is so pinched that she loses speed will also lose her lateral resistance, and make leeway. As soon as a yacht starts to crab to leeward, it is time to sail her more freely. A yacht should "go where she is looking"—in other words, sail the course she is steering without making leeway. There is always a certain amount of leeway, but if this is excessive, something is radically wrong either with the trim or with the design of the yacht herself.

As the yacht's course is changed in relation to the wind, the wind which was dead ahead comes round more to one side until the yacht can just lay the course without tacking. When this is so, the yacht is said to be able to "fetch" close-hauled. When the wind is round to two points forward of the beam ($22\frac{1}{2}$ degrees), the yacht will be in the position of making a "close reach." With the wind abeam, she is "reaching." With the wind two points abaft the beam, she has a "free reach." When the wind is anywhere abaft four points behind the beam but not dead astern, the yacht has a "quartering wind," and is said to be running with the wind. When the wind is dead astern, the boat is running dead before it. Winds are often spoken of as a "free wind," or a "head wind," and a close-hauled yacht is

said to be "on the wind," and a yacht with a free wind, "off the wind."

It will therefore be seen that the three points of sailing are beating to windward, reaching and running, and the novice has to learn to trim his boat to get her to any desired point under the varying conditions that he may meet.

Theoretically, the headsails and after-sails should make exactly the same angle with the keel, but this ideal can only be attained on a perfectly designed and tuned-up yacht. The majority require their headsail a shade closer than the after-sail in order to box them off if they get headed.

The theoretical angle of the sails for any given course can be calculated, but this is not likely to prove of any practical value, as there are so many other factors to be considered. Actually the sail of a yacht is not a flat surface, but forms a parabolic curve that varies with the force and direction of the wind. In addition, the angle of the sail from the vertical varies constantly as the boat heels, whilst the centres of lateral resistance and effort continually alter.

Another point that has to be borne in mind is the difference between the real angle of the wind to the course and the apparent wind. To explain the term "apparent wind," consider a steamship making 10 knots with a wind of 10 knots' velocity on the beam. Under these circumstances the smoke will blow out, not at right angles to the course of the vessel, but at an angle of four points abaft the beam, so that the apparent wind is four points ahead of the beam. This fact explains why a very close-winded yacht appears to be sailing to her own burgee, whilst a flag ashore shows the true wind to be about four points off the bow.

The skipper will therefore have to find out by experiment the trim that suits his boat under each and every condition of sailing.

* * * *

Beating to windward is always regarded as the supreme test of a vessel's capabilities, and it is sometimes said that you can get any boat

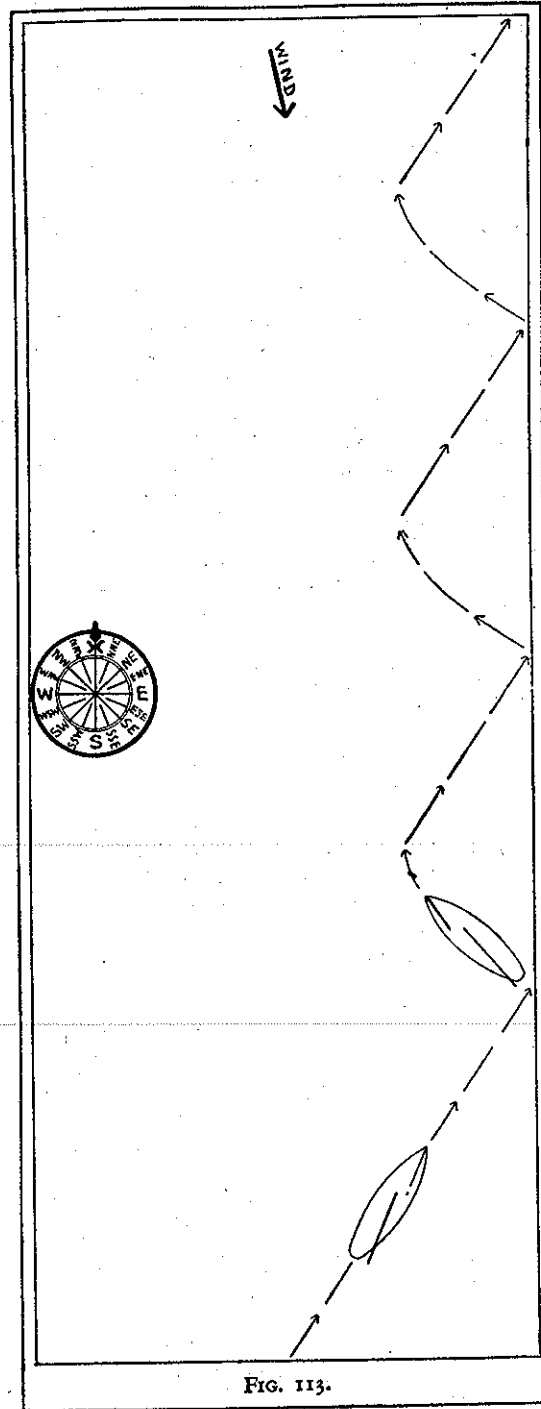


FIG. 113.

to run and reach. To a certain extent this is true, but to do really well on any point of sailing a boat must be properly balanced and trimmed.

It is by no means an easy matter to get a boat tuned-up to the finest pitch for windward work, but after that has been done and the correct windward trim found, it can be repeated indefinitely. Once this is an accomplished fact, windward work is really easier for the skipper than either running or reaching.

If the yacht is being sailed against the wind down a long narrow pond, the best plan is to sail from side to side in long tacks, getting a friend on the opposite side of the water to put the boat about as necessary. The mainsail should be hauled in to an angle of about 15 degrees, using the beating sheet, the running lines being slack so that no pull comes on the helm. In sailing from side to side of the lake, the centre eye on the jib-horse traveller is used, and the sail should be trimmed to the same angle as the mainsail. When the sails are trimmed, the boat can be put into the water. She should be carefully pointed in the right direction with the sails full and drawing, and allowed to sail off from the hand. If her trim is correct, she will then sail away on the tack selected.

As the steering gear is not used going to windward, the yacht's course must entirely depend on the balance and trim of the sails.

It is not likely, however, that the yacht's best trim for windward work will be found on the very first board of all, and her behaviour should be carefully noted. If the model does not point up to windward as she should, the jib is too close or the mainsail too far out, and a slight alteration can be made in the trim accordingly. The novice is strongly advised *not* to make violent alterations of trim, and if the mast position is approximately right, only slight alterations should be necessary.

Having found the best windward trim by experiment, the calibrations on the booms will enable this trim to be reproduced at will at any time.

It must be impressed on the tyro that no boat can sail dead against the wind, and if the

sheets are hauled too flat, the boat will be killed, and not sail properly. It is a great mistake to sail a boat too closely hauled, as she will lose speed and sag to leeward.

All ponds are not suitable for sailing from side to side, and also the wind along one shore is frequently better than the other. Under these conditions it is advisable to keep in the best of the wind and sail down the lake, making a short leg off and a long leg on. In order to do this, it is necessary for the yacht to put herself about at a suitable distance from the shore. This is effected by using the beating guy.

In order to make the yacht tack, the guy is hooked on on the weather side of the yacht as she leaves the bank. The tension of the elastic should be so adjusted that the wind can stretch it out fully until the sail is pulling on the ordinary beating sheet. The jib-sheet is hooked on the lee side of the traveller so that it gets a little slacker sheet on the off-shore tack. Another method of effecting the same thing is to insert a piece of cork under the jib-sheet horse on the windward side as the boat sails out. The sheet can then be trimmed a little easier on the off-shore tack, and the shorter horse on the other side will ensure her a slightly tauter sheet on the long leg. The slightly slacker jib-sheet helps the boat to come up into the wind.

The actual effect of the guy is that it gradually hauls the mainsheet closer and causes the boat to luff into the wind, and finally to come about.

If the boat flings about before she has gained an offing, it is a sign that the guy is too drastic in its action, and a slacker guy should be tried. If it does not act quickly enough, or the boat refuses altogether to come about, the guy is not strong enough.

The course of a boat beating down a lake by making short tacks on the guy is illustrated in Fig. 113. The pond in this diagram is twice as long as that in the earlier figures in this chapter. The course is from South to North and the wind N. by W. The first leg on the port tack she sails N.E. by N. On coming to shore she is put round on to the

starboard tack heading N.W. by W. On this tack the guy is operative, and as it hauls the boom in she gradually luffs till she comes head to wind and then fills away on the port tack again. The yacht is shown out of proportion to the pond, as otherwise it would not be possible to show the sail trim.

Some boats come up into the wind all right but refuse to pay off smartly on to the new tack. Many a race has been lost in this manner, and *if all else fails* a Liverpool Boy can be fitted to box the boat's head off when she has come head to wind. Some boats are most difficult to guy, and these can be fitted with a rudder guy. Heavy boats in strong winds often show this fault, and faulty guying is not easy to rectify, except by a rudder guy. The rudder guy is, however, violent in its action, and rarely allows the boat to gain a sufficient offing before she comes about. Its action can be regulated by the position it is hooked into the quadrant, and also by using the slide on the steering gear as a check. Some skippers hook their rudder guys into the tail of the quadrant and rely on the slide to regulate its action.

One cause of boats refusing to guy properly is that the boom lifts and the leach of the mainsail spills so that the sail loses power. Too heavy a guy in light weather may cause a boat to turn tail and bolt. The use of the guy cannot be imparted and must be gained by actual experience.

In sailing to windward, care must be taken that the helm is not being actuated by the running sheets. Some skippers prefer to lock their rudders amidships, but the best plan is probably to close the slides right up to the rudder-head when the rudder will have just a fractional amount of play.

In sailing just off close-hauled in a very light wind, an experienced skipper will sometimes use a fractional amount of jib steering to ensure his yacht keeping full and bye. In close-hauled work and close reaching, the beating guy should always be put on the leeward side of the boat. As long as the yacht remains on her correct tack it will remain idle, but should she come about

accidentally, or the wind draws ahead, it will ensure her remaining on the right tack.

Close reaching is always a difficult point of sailing. The beating sheet should be eased off somewhat and a little jib steering given to keep the boat full. The tension should be the slackest that will do the work, and about four holes out from the centre of the quadrant may be tried as a commencement.

When the wind comes abeam and it becomes a true reach, the jib steering can be unhooked and the mainsail steering brought into use. The beating sheet is unhooked from the horse and the sail trimmed by means of the running sheets. The sail pulls on the weather sheet, which can be hooked about two holes out from the centre of the quadrant for a start, and as slack a tension used as will do the work.

A good way to trim the sheets for reaching is to point the boat in the direction she has to go and ease out the sheets until the sails spill. Then pull in a little till they are drawing well. The yacht should not be sailed with too tight sheets and kept on her course by force of helm. This is bad sailing, and will not get the most speed out of the boat.

As the wind comes farther aft, both sheets are eased off. On a reach the jib is a most important pulling sail, but as the wind hauls more abaft the beam, the sail does less and less work until the yacht is running, when it is becalmed in the lee of the mainsail.

When the wind is about four points abaft the beam, provided it shows no inclination to head the yacht, the spinnaker can be set well forward. The spinnaker sheet should be hauled fairly well in under these conditions until it draws properly. It must be remembered, however, that the spinnaker is doing its best work when it is bellying full, and that a flat spinnaker will kill a yacht's pace.

As the wind comes more and more aft, the mainsail is eased off, and the spinnaker aft-haul pulled in until such time as the wind is dead aft. The main boom is then eased off as square as possible so that the sail can still operate the helm without the boom taking on the lee shroud, and the spinnaker boom hauled round to one point ahead of the beam.

It must never be hauled round quite square. The spinnaker sheet should be eased well off so that the sail has every chance to belly out and lift the boat along.

When the wind is practically dead aft, should the boat run off more until she gets by the lee (with the wind on the same side of the yacht as the sail), she will be very prone to gybe (*i.e.*, the mainsail fly over as the wind gets on the wrong side of it). Under such circumstances the kicking strap will come into play and prevent the boom skying. The tightness of the kicking strap will depend on the amount of wind. In a light wind it should not be too tight or it will hold the boom down and prevent the sail from bellying out properly. In a real racing yacht, it is customary to take the weight of the boom off the sail by means of the topping lift, when running in light weather. The object of this is to allow the sail to belly.

When reaching, it is asking for trouble if the novice tries to run jib and mainsail steering concurrently, but when the wind comes so far aft that the jib is practically idle in the lee of the mainsail, the jib steering can be brought into use most effectively at the same time as the mainsail. If only the mainsail steering is used and the model suddenly gets a slam that causes her to broach (*i.e.*, swing round broadside to the wind), the mainsail steering gear will then cease to function, as the sail will be too far out for the wind to put any pull on the sheet at the angle to the wind at which the boat then is. If, however, the jib steering has been hooked on, the jib will now be broadside to the wind, and actuate the helm strongly, and thus bring the boat back to her original course.

Conversely, if the yacht runs off too far and gets by the lee, the jib steering will also be very useful. When a yacht gybes, her jib always flies over before her mainsail. As soon as the jib gybes over, it will start to pull on the lee (or idle) steering line. This pull will be on the opposite side of the quadrant to that being exerted by the mainsail, and will neutralise part of the pull from the mainsail and so ease the helm. The boat will then come up slightly, and the gybe be averted.

When the jib and mainsail are drawing on opposite sides, the sails are said to be "goose-winged."

During running, the lee (or idle) running sheet on the mainsail should be hooked out towards the extreme end of the quadrant. Should the yacht accidentally gybe, this will then exert an excessive pull on the helm and gybe her back on to the correct tack.

* * * *

The use of the Braine steering gear, whether running or reaching, is governed by the same broad principles. The pressure of the wind on the sail causes the helm to be actuated, so that the puffs which tend to throw the yacht off her course actually give her sufficient helm to keep her on her course. The gear works so as to steer the yacht at a given angle to the wind, and nothing can guard against a sudden shift of wind, but given a wind of steady direction, the yacht should be able to be kept accurately on her course.

In trimming a yacht, the first consideration is to set the sails at the angle to the wind which will give the maximum efficiency in relation to the course which it is desired to make. The moment the wind strikes the sails of a fore-and-aft vessel, it has a tendency to make the hull revolve. The function of the rudder is to counteract this. In other words, the use of the helm is to keep the hull pointing in the desired direction and thus permit the sails to exert their full power.

The various parts of the steering gear have been described in a previous chapter. The advantage of the quadrant form of steering gear over other types is that it maintains its power to function correctly under any given combination of circumstances.

As will be seen from the diagrams in previous chapters, the gear is arranged to actuate the rudder so as to give what is known as weather helm on either tack. This is done by making the boom pull on the weather sheet, and it will be noted that in order to do this, the running sheets have to cross from the weather side pulley to the leeward arm of the quadrant. It will therefore be seen that the power of the gear can be adjusted indepen-

dently on either tack. With any given strength of wind, the power of the sail to actuate the rudder is entirely dependent on the amount of leverage. Obviously, the amount of leverage on the quadrant is varied by the distance the running sheet is hooked out from the centre of the quadrant, whilst the tension of the centering-line can be altered by means of the bowser. By the correct use of these two adjustments in combination, it is possible to provide for the boat to get the right amount of helm to counteract the turning moment of the sail and to adjust this to varying strengths of wind automatically.

It has already been impressed upon the reader that the rudder must work with the minimum amount of friction. The helm should respond readily to the slightest zephyr on the mainsail. To attain this, the tension of the centering-line should only be just sufficient to bring the rudder back amidships when there is no pull on the running sheets. In consequence, the leverage of the sail must be correspondingly limited, and the running sheet will only be a few holes out from the quadrant head.

Now, although the old hand may get his adjustments right at the first attempt, the tyro is not likely to be so successful. If the sails are correctly trimmed and the boat does not hold a true course, it is obvious that the steering gear needs adjustment. In order to do this successfully, the boat's performance must be analysed.

If upon starting the boat on a course down wind it is found that she does not keep away before it, it is obvious that sufficient power is not being exerted by the rudder, and the leverage of the sheet must be increased by hooking further out on the quadrant. On the other hand, she may keep away too much, and in this event the leverage must be decreased.

It may, however, be found that after sailing correctly for some distance, a variation in the strength of the wind causes a deviation from the course.

Now, if she holds her course in the normal weight of wind and shows a tendency to luff into the wind during the heavier puffs, it will

be necessary to give more leverage by hooking out further on the quadrant. Should, however, she show a tendency to run off in the harder puffs, it is a sign that the leverage is too great. A tendency to steer up into the wind when it falls lighter is a sign that the centering-line is too tight, but if she falls away under those circumstances, it proves that the rudder is too easily actuated and the centering-line should therefore be tightened.

It is possible that in the correction of one fault the novice may create another. For instance, if in order to correct luffing in the slams one gives more leverage and then finds that she falls away in the normal weight of wind, it proves that, with the new position of the running sheet, the centering-line is too slack.

The correct use of the steering gear is only a matter of mastering the principles enumerated above and applying them intelligently. It must, however, be emphasised that the adjustment of the centering-line is a very delicate matter, and only small alterations in this should be required.

As was mentioned in the chapter dealing with the fitting-up of the steering gear, it is important to have the rubber in the centering-line of such a length that it is equal fore-and-aft of the tail of the quadrant. In other words, the hole in the tail of the quadrant is at the middle of the rubber. The object of this is to eliminate any tendency for the rubber cord to move backward and forward through the eye of the quadrant, thus creating friction that interferes with the efficient functioning of the gear. Many model yachtsmen, who should know better, bring this fault into being by the improper use of the tension slide.

The tension slide was originally devised merely to hold the rudder amidships when going to windward and so eliminate the pinrack. It was, however, found that the slide could also be used as a check upon the angle of the rudder. This has, unfortunately, led to its abuse, as it is often wrongly used for trimming purposes, thus destroying the even balance of the rubber. If, however, the rubber is correctly arranged, the slide can be employed with advantage for a quick retrim during a race, but its use should be limited to

this, and it should *on no account* be used for actual trimming.

A very important factor in the correct functioning of the gear is the point of attachment of the running lines to the boom. The closer the pulling point is to the gooseneck, the greater the strain on the running lines for any given strength of wind, and *vice versa*. It therefore stands to reason that if the point of attachment is brought as far aft as possible the strain on the gear will be minimised, and the tension of the rubber centering-line can be less. The helm will then be more sensitive to fluctuating strengths of wind.

The position of the pulleys is also very important. Theoretically, it would be best for the pull to come always on the centre line of the yacht, but this is not possible. The pulleys should therefore be as little off the centre line as is consistent with their correct functioning on opposing tacks. They must of course be sufficiently far apart to obviate any risk of both lines pulling at the same time and interfering with the action of the gear. In this connection it must not be forgotten that the boom rises when the sail is pulling hard. If the pulleys are too close to the quadrant or too far apart, there is a risk that the radial arm of the quadrant may tend to become an increasing lever arm as the quadrant swings on its axis. If this happens, the whole principle of the gear is nullified. The diagrams in earlier chapters show the right way of fitting up a steering gear.

Round moulded rubber gives better results for the centering-line than any other, and silk covered elastic is useless, as it is already in tension and cannot therefore possess a proper resiliency. For an A-class model, $\frac{3}{16}$ in. will be about the right thickness, but both the length and thickness of the rubber are to a large extent governed by the length of the tail of the quadrant. A shorter tail requires a relatively shorter rubber.

It must be remembered that a fault in design always has some form of steering effect when the boat is travelling, and the measure of both the defect and its effect will vary with alterations in the angle of heeling and speed through the water. The steering gear is

powerless to remedy a defect that is inherent in the hull. If there is a defect in the stern of the boat, particularly near the rudder, it is certain to impair the correct functioning of the helm. The reader will, however, have already perused the chapters on designing, and there is no need to repeat what has already been written in this context.

* * * * *

In tuning-up a boat, the position of the

centre of effort is too far aft. Under such conditions the jib has to be kept iron hard and backwinds the mainsail, with the result that neither is doing its work properly. The cure for these faults is to move the mast aft or forward as the case may require.

When the correct position for the centre of effort has been found, the boat will sail to windward with the jib and mainsail trimmed to exactly the same angle. As the boat travels

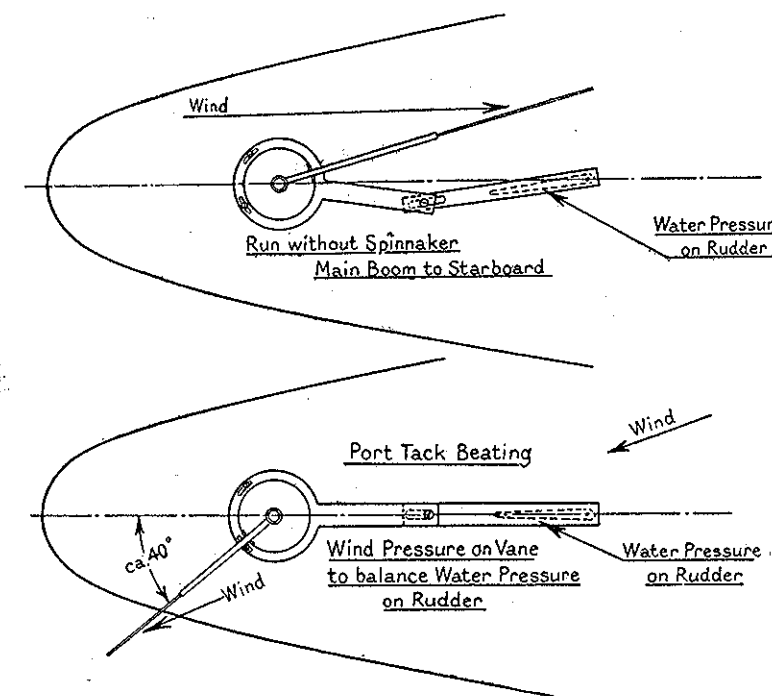


FIG. 114.—HOW TO SET THE VANE GEAR.

Upper diagram: Setting for running without spinnaker. Lower diagram: Setting for beating to windward.

mast for windward work is the first and most important point. In considering this, it must be remembered that it is really the centre of effort of the sail-plan that is under review, and this is automatically affected by any alteration in mast position, which is what is needed under certain conditions.

If a boat falls off and refuses to point to windward, the centre of effort is obviously too far forward. If, however, she shows a tendency to go into irons with her sails correctly trimmed, it is equally plain that the

to windward under this trim, the luff of the mainsail will give just an occasional slight flicker. The drive going out of this part of the sail will then ease the pressure of the after-sail slightly, and the jib will pull her head off just a fraction until she is full and bye once more. This action is, of course, so slight as to be almost imperceptible, and the yacht keeps forging ahead fast all the time and never stops or slows in her gait. Experience will tell one when the trim is just so, but it may be described as a combination of perfect

MODEL SAILING CRAFT

balance between the sails, correct mast position and sheet trim.

When once the correct mast position has been found, it should never be altered. As the sails are trimmed farther off the centre of effort moves forward, and this will be sufficient to keep the yacht at her work until the wind is so free that the helm must be used.

Another very important point is the rake of the mast. An alteration in rake will alter the position of the centre of effort, and, in addition, it alters the angle of drive. Quite apart from the position of the centre of effort, mast rake will have a marked effect on a yacht's performance. Some boats are made fidgetty by too much rake, whilst others require rake to make them point properly. This will be a matter for experiment.

* * * *

The greatest exponent of the Vane gear is Mr. Sam O. Berge, who very kindly gave the following hints for its use:—

In order to get good results with the Vane gear it is necessary to have the sailplan considerably further aft than when using the Braine gear. For an A-class the mast would have to be moved between 1 and 2 in.

To sail a steady course close-hauled, it is necessary to have wind pressure on the lee side of the vane to counteract the water pressure on the lee side of the rudder. The vane should have an area about three times that of the rudder. Beating to windward, using the Vane gear, the jib can be rather more free than when sailing to windward without helm as is done with the Braine gear. The jib will then pull well without back-winding the mainsail. Tuning up, start with the vane 40° – 45° from the centre, and move the mast aft until the best position is found. The mainsail should be trimmed as usual but the jib slacker.

For guying, the sails and vane are trimmed for the long leg. When the boat comes ashore she is simply turned round and put off without altering the trim. She will then make a short leg off and come about as if she was on a rudder guy. For a longer leg a pinrack might be used to check the action of the vane somewhat on the off-shore tack.

Sailing to windward leg and leg, the vane has to be put over for each tack, but its movement can be limited to exactly the right amount by using the screws on the quadrant disc. The setting of the vane for windward work is seen in the lower diagram in Fig. 114.

The upper diagram in Fig. 114 shows the way to set the vane for a run without spinnaker. With a spinnaker less helm is needed. Running it is advisable to use a boom guy to prevent the boom gybing, particularly at the start. When the model comes ashore on the lee bank the trim can be quickly altered by giving about 5° less helm. If she comes to the weather bank, well down the lake, it is probably advisable to gybe the boom and set the vane about dead-centre forward. With spinnaker set, one should try to keep away from the weather shore, especially if the water is at all low.

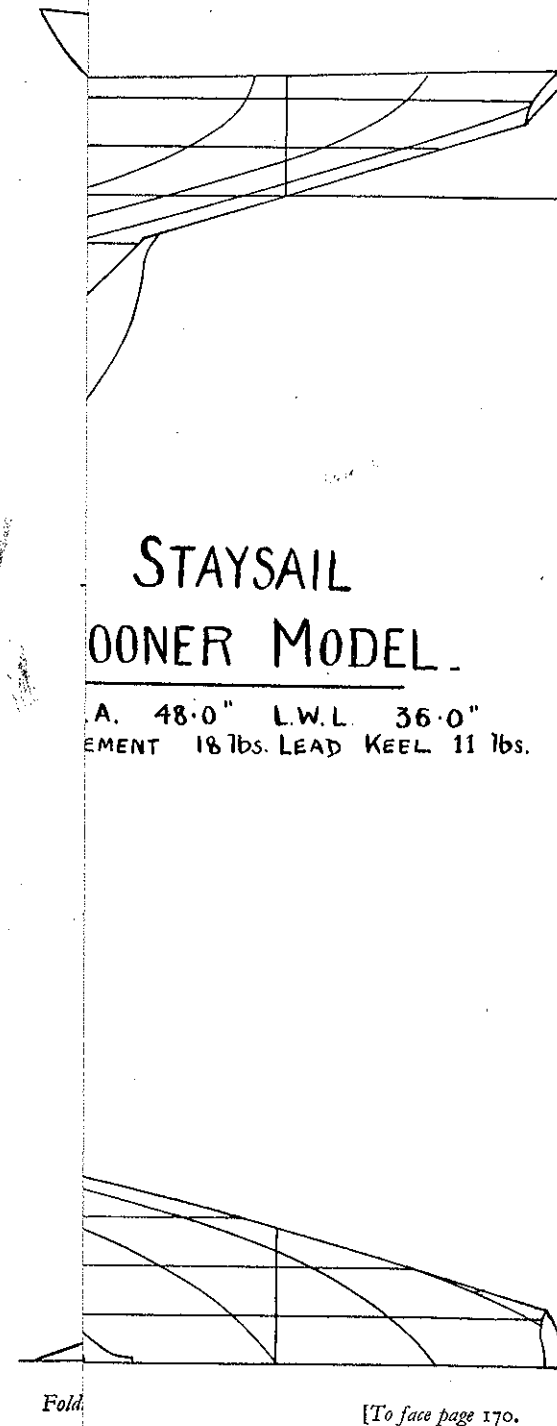
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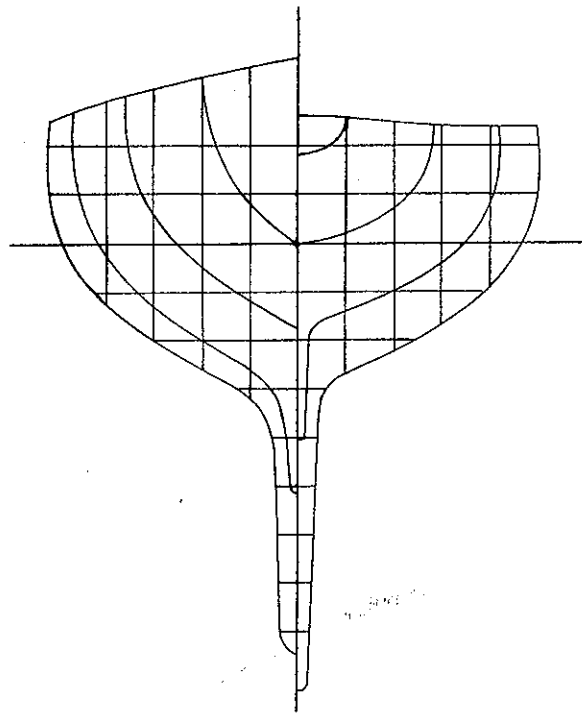
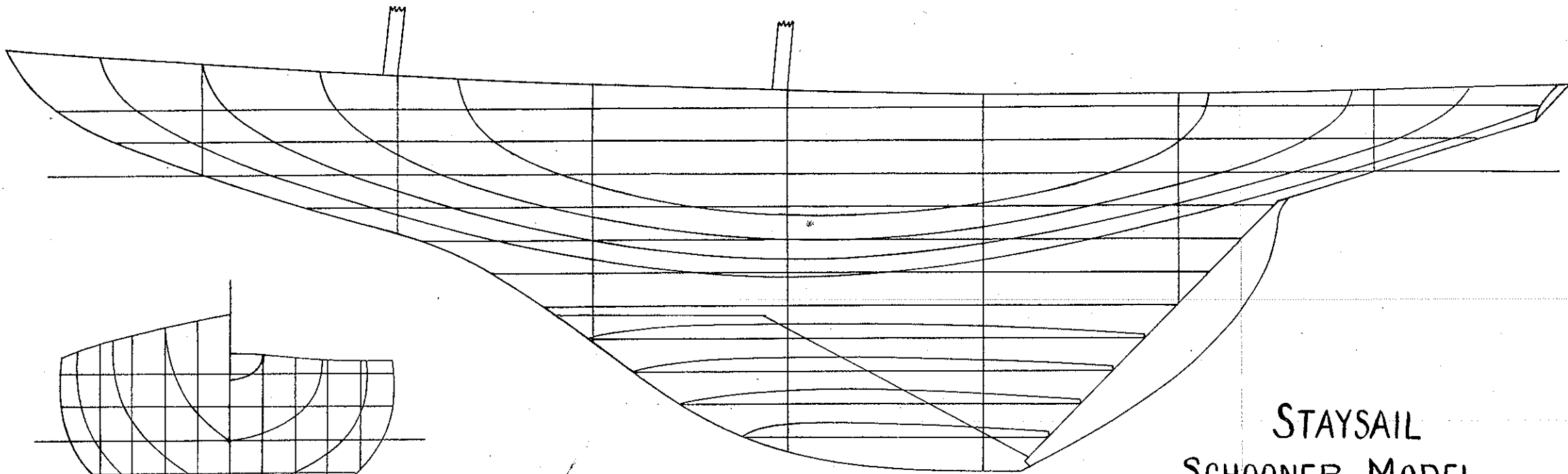
In wet weather sheets shrink and allowance has to be made for this. It is to obviate this that many keen racing men use fine chain instead of cord for their jib sheets and beating sheet. At the same time the actual shrinkage of the sails themselves makes a considerable difference. Halliards and outhauls also require to be eased up in wet weather in order that the sails may not be pulled out of shape. Care should also be taken that the jib halliard or the forestay do not put a kink in the mast.

Another little point to look to before each board is that the rudder is perfectly straight. A little knock may put the rudder just out of central and cause most unexpected results.

If the boat is found to be performing differently on opposite tacks, the rudder should be examined to see that it is dead amidships. If this is found to be correct, the mast should be checked to see that it is not out of the vertical, and it should also be noted that the amount of sheet is the same on each tack. If all these are correct, the fault must lie in the hull, which cannot be true.

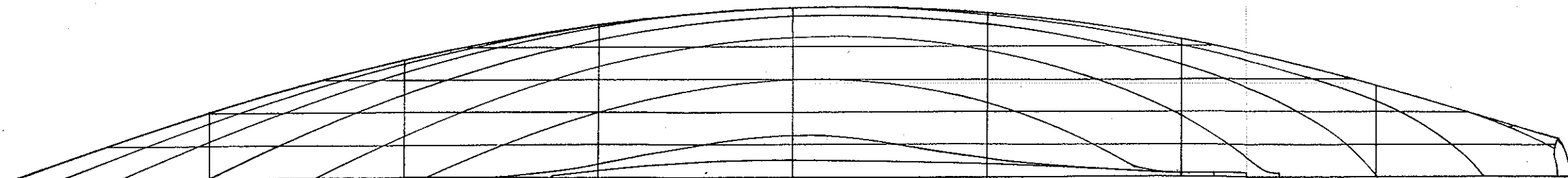
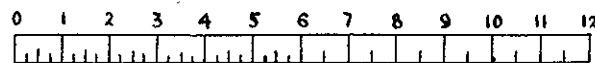
Finally, it must again be emphasised that it is a mistake to pinch a boat to windward unduly, as she cannot then do her work properly. Directly a boat starts to make excessive leeway, ease the sheets off.





STAYSAIL SCHOONER MODEL.

L.O.A. 48.0" L.W.L. 36.0"
DISPLACEMENT 18 lbs. LEAD KEEL 11 lbs.

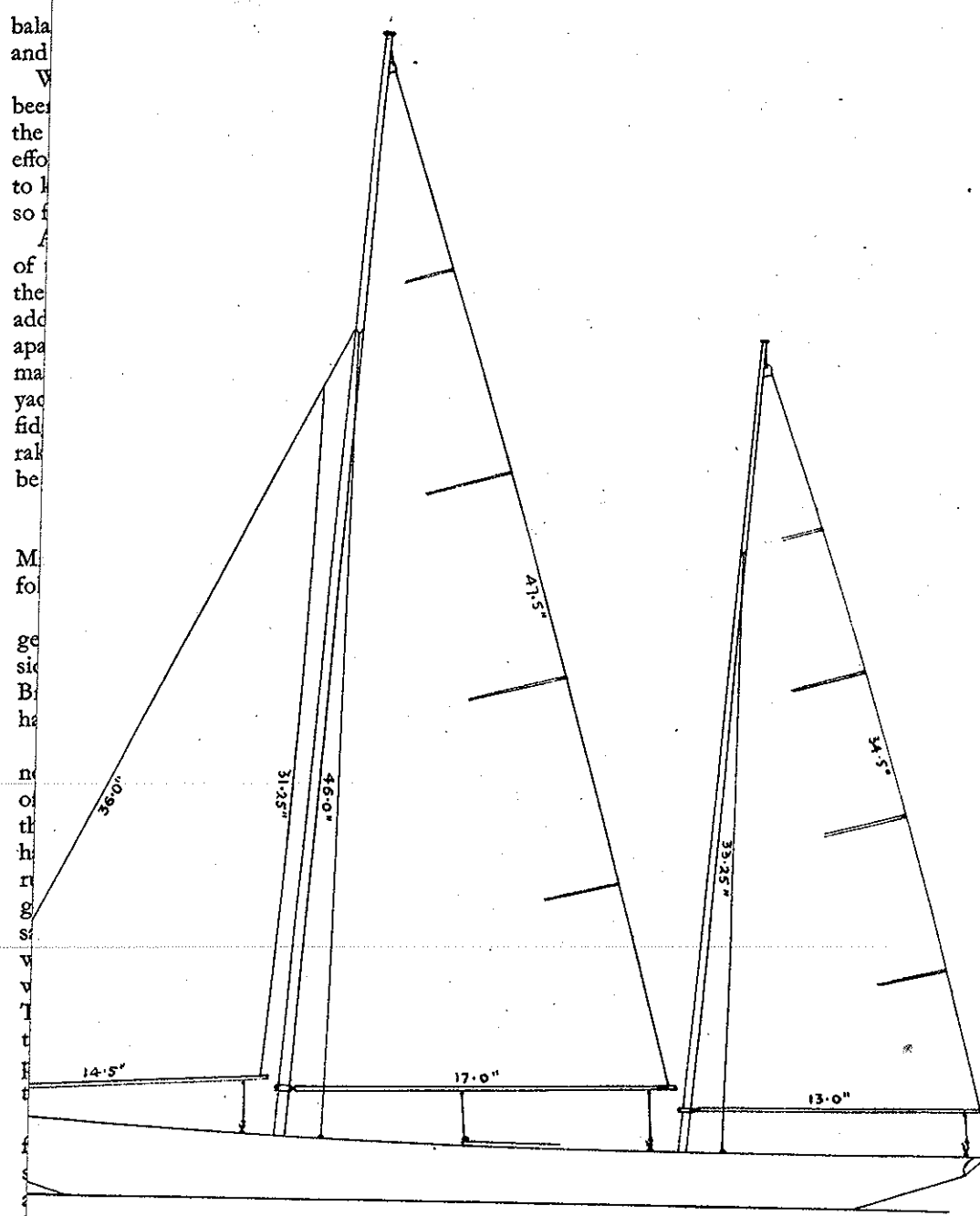


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ALTERNATIVE SAIL PLAN AS BERMUDA KETCH.

[To face page 171.]

CHAPTER XXI

Fore-and-aft Rigs with their Salient Characteristics. Square Rigs.

EVEN when the model yachtsman is not building a racing craft, he will be well advised to build a fore-and-aft rigged model, as model square-riggers are not so satisfactory as fore-and-afters for model sailing purposes. Moreover, they take too long to rig and unrig at the pondside, and are more

In dealing with the various fore-and-aft and square rigs, only the principal ones can be mentioned, as there are so many hermaphrodite rigs that are not exactly one thing or the other. Single-sail rigs are described first, as there are numerous sub-divisions of other rigs governed by the different kinds of mainsails.

The oldest form of lug is the *Dipping Lug* (Fig. 115). This is very close-winded, but has to be lowered and re-set on the leeward side every time the boat is tacked.

The *Standing Lug* is an improvement on the dipping lug. In this sail the tack, instead of being made fast to the weather gunwale forward of the mast, is made fast to the after side of the mast. The standing lug occasionally has a boom.

The *Balance Lug* is a development of the

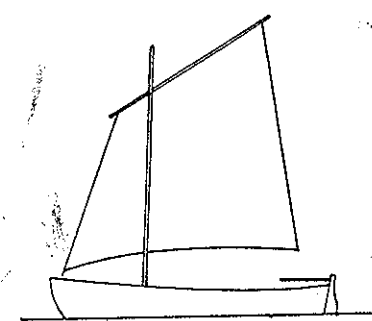


FIG. 115.—THE DIPPING LUG.

troublesome to trim. At the same time a square-rigged model looks well under way, and as there are many to whom the type appeals, a method is outlined at the end of this chapter whereby trimming may be simplified.

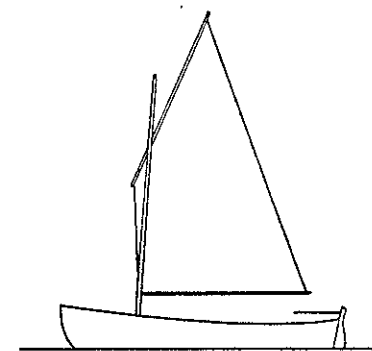


FIG. 116.—THE STANDING LUG.

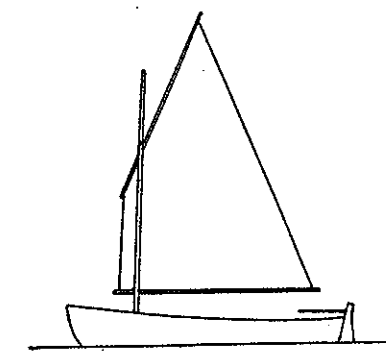
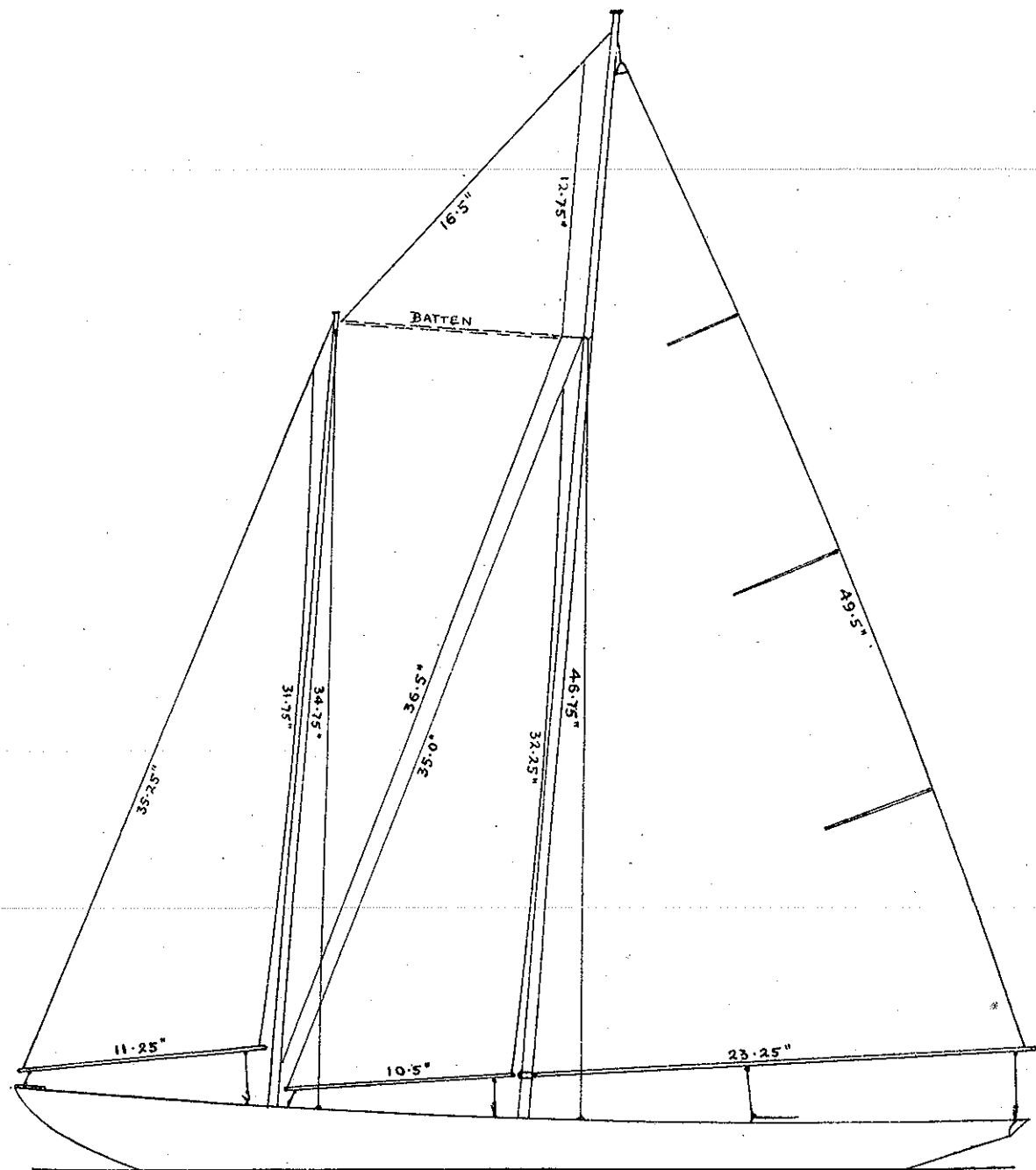


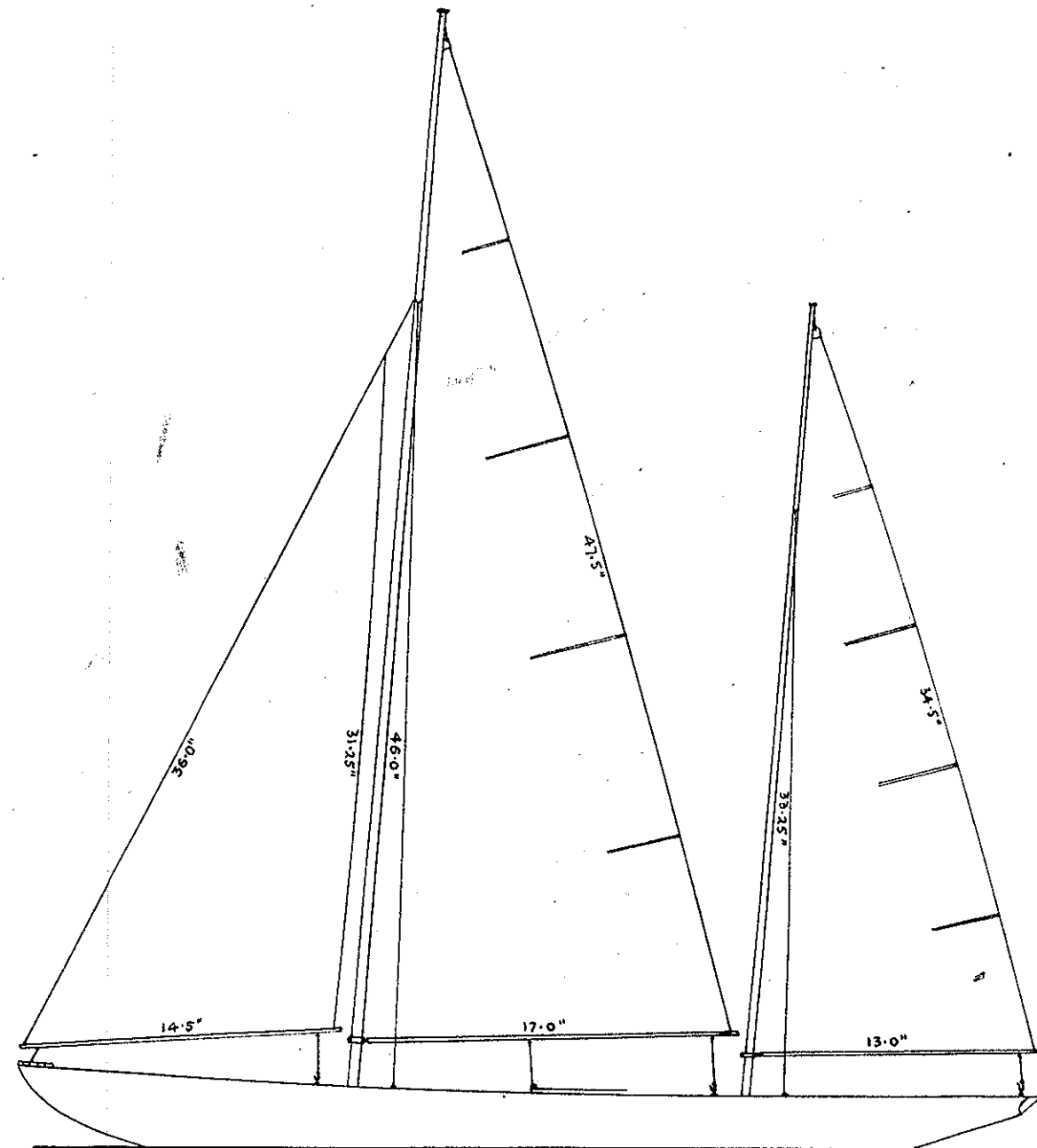
FIG. 117.—BALANCE LUG.

standing lugsail, and has a boom. Part of the sail is forward of the mast and the boom is pulled down with a tackle. It is an excellent form of sail for small craft, easily handled, close-winded and efficient.

Another variety of lug sail is the *Gunter Lug*, which is more than half-way between the ordinary gaffsail and the Bermuda. The spar



SAILING PLAN OF STAYSAIL SCHOONER.



ALTERNATIVE SAIL PLAN AS BERMUDA KETCH.

MODEL SAILING CRAFT

which extends the head of any kind of lugsail is known as the "yard," not the "gaff," as on the ordinary type of sail. The yard of a gunter is frequently curved (as shown in the diagram)

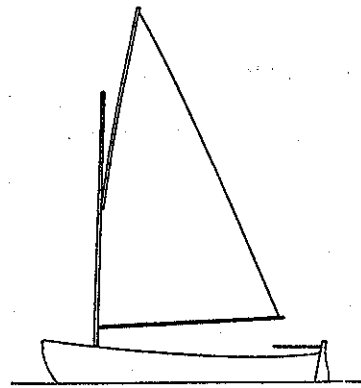


FIG. 118.—GUNTER LUG.

with the object of bringing the head of the sail into line with the luff and increasing the triangular effect.

The Catboat (or Una).—Single-sailed boats with the mast stepped well forward and an

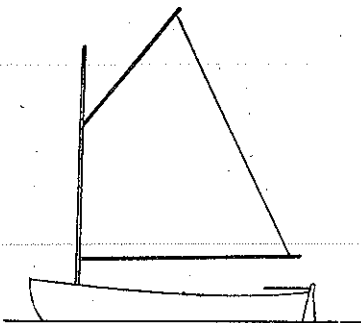


FIG. 119.—CATBOAT WITH ORDINARY GAFFSAIL.

ordinary gaffsail are frequently called by this name. Catboats are usually small craft. They are unpleasant boats, but have the merit of simplicity. In the model a single-sailed boat is impossible to balance properly.

Some unas have a leg-o'-mutton (or *Bermudian*) sail. The name "Bermuda" or "Bermudian" is given to the leg-o'-mutton (tri-

angular) sail, and is taken from the celebrated Bermuda racing dinghies. Besides a triangular mainsail these boats carried an enormous jib set on a long bowsprit. Their sail area was

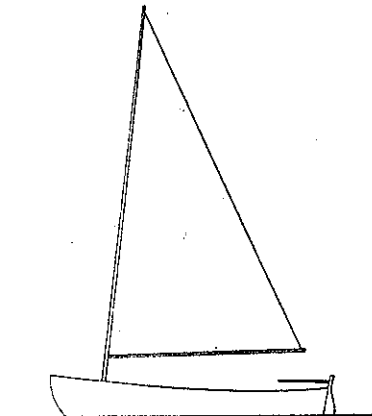


FIG. 120.—BERMUDIAN CAT.

large and they relied on a numerous crew to sit them out.

The only other type of sail used on single-sailed craft is the "*Spritsail*." This is used on many smacks' boats and similar craft. It is very simple to set, and has the merit that

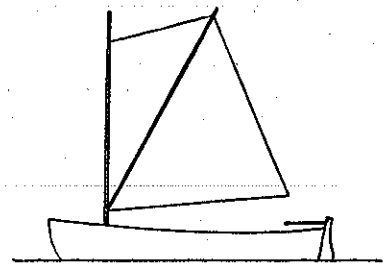


FIG. 121.—THE SPRITSAIL.

it can be brailled up out of the way in a moment.

The Sloop.—The addition of a single headsail to any of these rigs transforms it into a sloop. The term "sloop," without any qualification, is used to imply a boat rigged with an ordinary gaff mainsail and a single headsail. She may have no bowsprit or a

FORE-AND-AFT RIGS

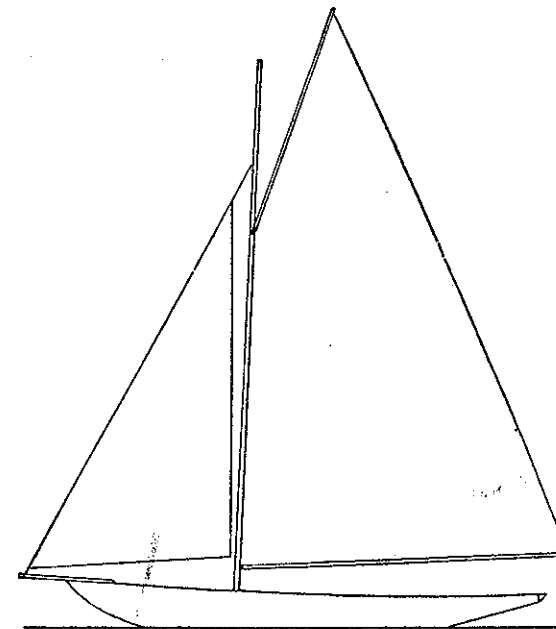


FIG. 122.—THE SLOOP.

short bowsprit. The gunter sloop has a gunter lug as mainsail and a single headsail,

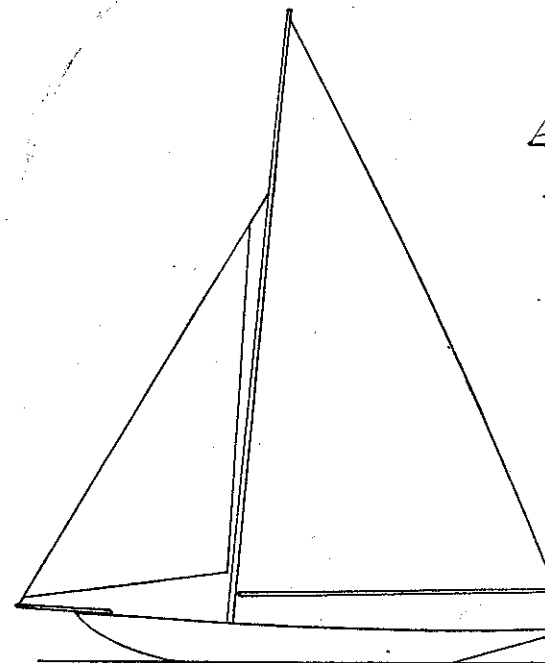


FIG. 123.—BERMUDIAN SLOOP.

whilst the Bermuda sloop has a Bermudian mainsail and a single headsail. The standing lug is used with a jib on the Yorkshire Cobles, and various other craft use dipping lugs, balance lugs, and occasionally spritsails in combination with a jib.

The Cutter.—The name cutter is given to a vessel carrying two or more headsails upon a bowsprit. Where there are three headsails, these are outer jib, inner jib and staysail. A

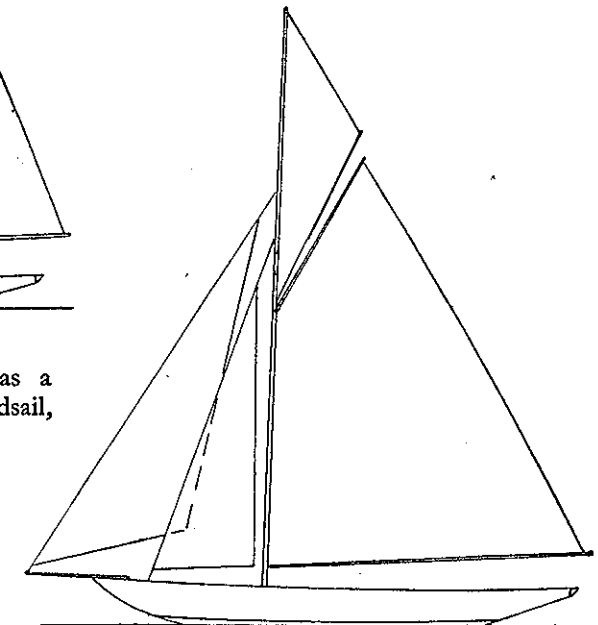


FIG. 124.—THE CUTTER.

cutter usually sets a topsail above her mainsail. The respective names of the sails on the cutter in the diagram are the mainsail, foresail (or staysail), jib and topsail. On occasion cutters also carry a jib topsail.

The Yawl.—The great drawback to a large cutter is the size of the mainsail and the length of the mainboom. In order to obviate this, the mainboom is shortened and a small mizzen added. The yawl usually has a gaff-headed mainsail and mizzen. The latter said is sometimes triangular. When the mainsail also is triangular, the rig is known as the "Bermuda Yawl." In order to sheet the small mizzen properly, a bumpkin is fitted as shown in the

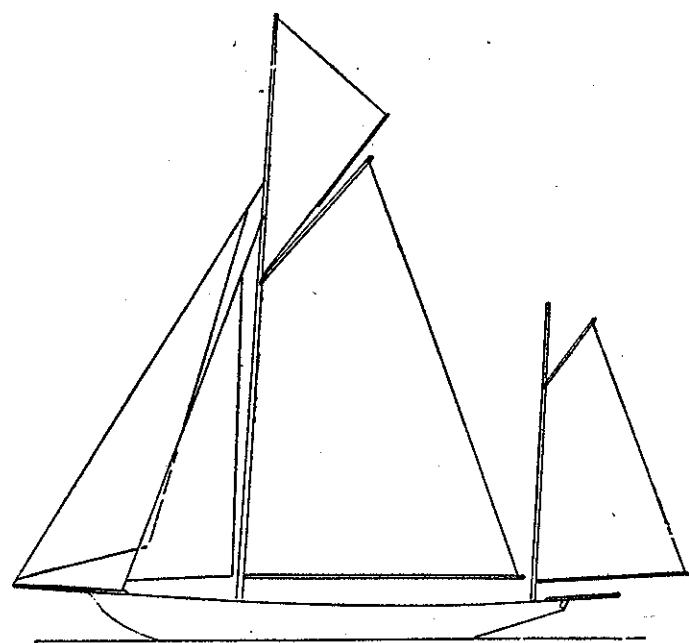


FIG. 125.—THE YAWL.

diagram. In a yawl the mizzenmast is aft of the rudderhead.

The Ketch.—The mizzen on a yawl is almost

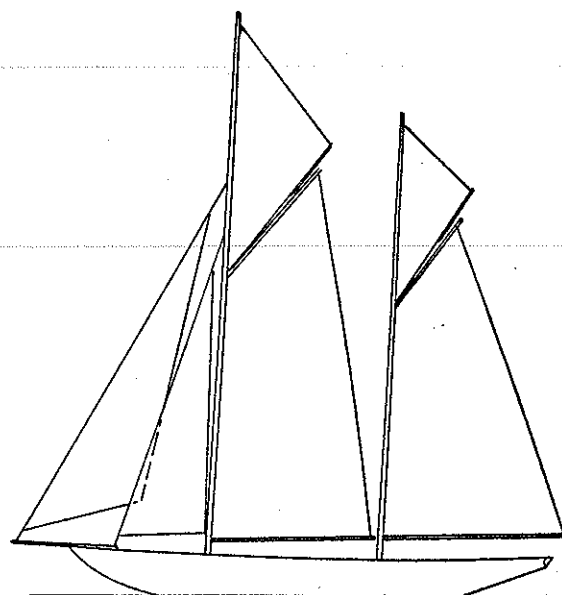


FIG. 126.—THE KETCH.

too small to be of any real use, and in the ketch the mizzenmast is placed forward of the rudderhead. In some ketches, the mizzenmast is so big that it is only just shorter than the mainmast. When the ketch has a big mizzen, a topsail is often set over it. As in the yawl, the mizzen is sometimes triangular, and when the mainsail also is triangular, the rig is known as a "Bermuda Ketch." The Thames barge is a spritsail ketch. The ketch is an efficient and seaworthy rig, and deserves its popularity for cruising purposes.

The Schooner.—When the after mast exceeds the forward one, the rig becomes a "Schooner," and the masts are known as the foremast and mainmast. The sails in the schooner shown are jib, staysail, foresail, fore topsail, mainsail and main topsail.

Although the schooner in the diagram has two masts, three-masted schooners are by no means uncommon, particularly in the American and Canadian coasting trade. The masts of a three-master are known as the foremast, mainmast and mizzen. Four-masted, five masted and occasionally six- and seven-masted

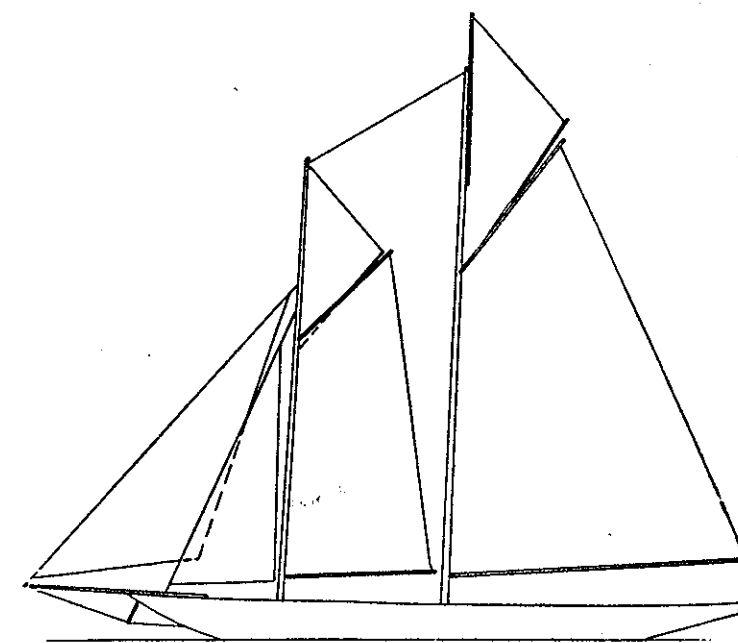


FIG. 127.—THE SCHOONER.

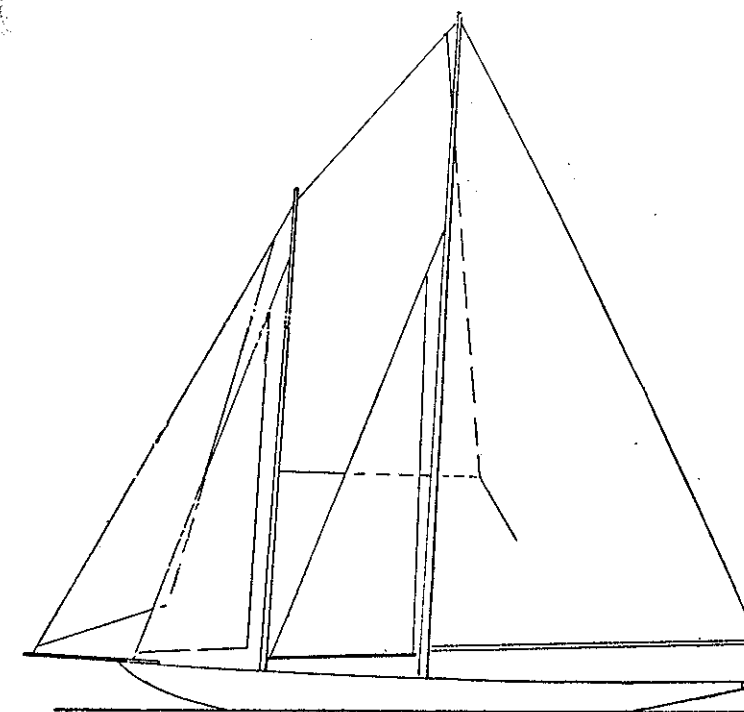


FIG. 128.—STAYSAIL SCHOONER.

schooners have been built. The masts of the latter were distinguished as "Sunday, Monday, Tuesday, Wednesday, Thursday, Friday and Saturday."

Schooners are occasionally rigged with a triangular foresail, as this obviates the difficulty of keeping the foresail gaff inboard, which is always present, owing to the high narrow cut of this sail. When a triangular mainsail is also used, the rig is known as a "Bermuda Schooner."

Modern discoveries in aerodynamics point to the efficacy of high, narrow, triangular sails and of staysails in particular, and the consequence is that a new rig has been developed in the form of the *Staysail Schooner*. This rig has not yet become stereotyped, but

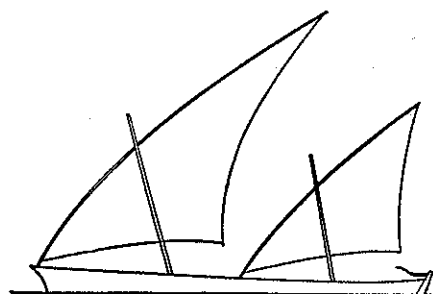


FIG. 129.—A LATEENER.

a typical example is shown in the diagram. The sails on this yacht would be called the jib, fore staysail, main staysail, triatic staysail and mainsail.

In addition to the above rigs, there are others, such as the Lug-Yawl, the Lug-Ketch, the Lug-Schooner, etc.

There are also a number of rigs based on the lateen sail. Ancient cutters used to carry a square topsail, and such craft are still found in the Eastern Mediterranean and other places.

The topsail schooner, although usually classified as a fore-and-aft rigged vessel, is, for the purposes of this book, included with the square-rigged vessels.

In our description of fore-and-aft rigs and also that of the square riggers which follow, no attempt has been made to classify the rigs of

ancient vessels or describe them, as this would appear to be outside the scope of the present volume.

* * * *

Before giving a catalogue of the various square rigs, it is as well to describe the masts and sails, as an understanding of these will simplify the explanation of the various rigs.

As will have been seen previously, vessels such as the yawl and ketch have two masts, of which the forward mast is greater than the after mast, and these are known respectively as the mainmast and mizzen. But in vessels having their after mast greater than the forward one, these are known as the foremast and mainmast respectively. When a vessel has three masts, these are foremast, mainmast and mizzen. When a fourth mast is added, this is called the jiggermast, and in a five-master, the masts are the foremast, mainmast, mizzen, jigger and pusher.

The lowest squaresail on any mast is the course, and the lowest squaresails are known collectively as the "courses" or "lowers." The course on the foremast is known as the "fore-course" or "foresail," that on the mainmast as the "main-course," or more generally the "mainsail," and that on the mizzen is known as the "crossjack" (pronounced cro'jack) when there are three masts. The cro'jack is always the lower on the after mast.

The squaresails above the lowers are the topsails, and these take their names from their respective masts. Above the topsails are the topgallants, which are similarly identified by their masts. Above these are the royals, and above these again the skysails. For convenience in handling, particularly when economy of working became essential to meet competition, the later clippers had their topsails divided into upper and lower topsails. In some cases the topgallants were similarly divided.

Dealing with the fore-and-aft sails, the headsails (when these are three in number) are the outer jib, inner jib and fore staysail. A flying jib is also used in some ships. The

gaff-headed sail set on the after mast is known as the "spanker" (or "driver"). The staysails set between the masts bear the names of their respective stays, as the main staysail, mizzen topmast staysail, etc.

The above will enable the reader to follow the definitions of the various rigs.

The Topsail Schooner.—This vessel is rigged exactly like an ordinary fore-and-aft schooner, with the addition of square topsails on her foremast. The topsail schooner can have two or more masts.

Brigantine.—This is a two-masted vessel, square-rigged (including the course) on the foremast and fore-and-aft rigged on the mainmast.

Brig.—This vessel is square-rigged on each of her two masts, and carries a boom mainsail.

Barkentine (or Barquentine).—This is a vessel with three or four masts, and is square-rigged on the foremast and fore-and-aft rigged on the others.

Bark (or Barque).—There are three, four, and occasionally five-masted barques. This rig is square-rigged on all the masts except the after one. The ill-fated "Kobenhaven" was an example of a five-masted barque.

Ship.—The ship is a vessel with three or four masts, all being square-rigged.

In addition to these, there are one or two hermaphrodite rigs, but the above are the main categories of square-rigged vessels.

If the reader is desirous of rigging a showcase model of a square-rigger, he is referred to such works as Kipping's "Masting" or "Sailing Ship Rigs and Rigging" by H. A. Underhill, as space does not permit us to do justice to the subject here.

For a sailing model, it is advised that a single topsail rig should be chosen and nothing above the royals be fitted.

In sailing a square-rigged model, the crossjack is best kept clewed up.

Other modifications that can with advantage be made on a sailing model are to omit the sheets for the squaresails and make these fast at the yardarms, and to make all the lifts,

including the lowers, non-working. The braces can also be modified with advantage.

The lines of a real ship do not give sufficient displacement to get the necessary stability, and the lateral plane also is insufficient.

Readers who have studied previous chapters on design will appreciate that this is due to the scale on which the ship has to be reproduced, and that the best way to overcome this difficulty is to bodily increase the sections so as to give greater displacement on the desired length. Additional stability and lateral plane can also be gained by the addition of a false keel, which, if desired, can be made to unscrew when the ship is not being used for sailing.

A good method to rig a sailing model of a ship is as follows: In order to facilitate trimming, the yards are firmly clamped to the masts. The masts are fitted in round sockets, so that they can be rotated as desired. The lowers are fitted with booms, which necessitates the shrouds being carried well aft. The yards are fixed to the masts with brackets. These brackets carry the yards about $\frac{3}{4}$ in. forward of the masts, so that for beating when the sails are trimmed round, the centre of effort of the whole sail-plan is moved aft. The spanker sheet is made to operate the rudder.

In order to take the eyes for the staysail halliards, sheets, etc., loose collars are fitted to the masts. It is necessary for the sails on the foremast to be trimmed a shade closer than those on the main and mizzen, and consequently the brackets carrying the yards are not quite so long.

The braces are carried from the yardarms on one mast to those on another. The main-braces are the sole exception, and these are led to the quarters of the ship. It will be seen that by trimming the mainbraces, all the yards are swung and trimmed simultaneously.

Whilst this method of trimming is not absolutely perfect, it is the nearest thing that can be got on the model unless the skipper wishes to spend a good half-hour trimming braces and sheets every time the ship is put about.

CHAPTER XXII

Advice to the Novice on the Selection of a Class to Build to. Formation of a new Club. Summary of Racing Rules. Making out Match Cards.

IN the selection of a class to build to, the first thing to consider is the purpose for which the boat is to be used. If she is intended solely for cruising, the builder can follow his own inclination as to size and type, but if she is to be used for racing, it is a different matter. The best plan is to find out whether there is a club in the vicinity and inquire from the secretary the terms of membership and the classes of boats used.

Unless the pond where one intends to sail is very small, it is a mistake to build too small a model. At the same time, the owner must consider the distance that he will have to carry the boat, the facilities at his command for building, and what he is prepared to spend.

The character of the water must also be considered. It is useless to have a very large boat for a very small pond, and equally futile to have a very small boat for a large sheet of water. If the model cannot be handled from the bank, but has to be sailed from a skiff, this must also be taken into account, as a very big and powerful model is not easy to handle or keep up with unless a special skiff is available.

Whatever class is selected, if the novice intends to go in for racing, he is strongly advised to select the Bermuda sloop rig. Besides the theoretical and practical advantages set forth in the chapter on the Design of Sail-plans, there is another great practical advantage from the point of view of handling. The fewer complications there are about a boat, the less chance there is of making a mistake, and the man who makes the fewest mistakes wins the most races.

If there is no club within easy reach of the builder, and there is a suitable local sheet of water, the question of the formation of a new club may arise.

Obviously the first step towards the formation of a model yacht club is to collect a

nucleus of model yachtsmen. A letter in the local paper will often produce good results in this respect. As soon as six or eight enthusiasts have been found, a meeting should be called at some convenient place. Probably there is no choice of sailing waters, but if there is, select the most open and suitable one.

In the selection of a lake, the requirements for the ideal sailing water should be borne in mind. Possibly the selected water will not come up to this ideal in every respect, but the nearer it does the better.

The ideal sailing lake should have its longitudinal axis in the direction of the prevailing winds, so as to give as much beating to windward as possible. There should be no trees or buildings to break the wind from any quarter. Above all, they should not interrupt the course of the prevailing wind. The lake should be as large as possible within reason. There should be a good depth of water in the middle and the water should shallow somewhat towards the sides. If there is a sheer side, there should be about 18 in. to 2 ft. of water right to the edge. A greater depth at the edge is dangerous for children. If the boats are to be handled from the bank, the pond should have a concrete walk all round. If the boats are handled from the water by wearing rubber boots and wading, this is not so important, but there should be a firm dry footpath round the lake. The boats must be able to be handled at any part of the edge of the lake. If possible the length of the lake should be four or five times the width. An ideal length is 800 to 1,000 ft., though good sport is to be had on longer and shorter lakes.

The first thing that a new club requires is a name and the second a good secretary. The Secretary can make or mar the club, and the selected man must not only be able and prepared to give the time for the necessary work, but must also possess tact and patience.

SUMMARY OF RACING RULES

Another desirable thing is to interest local notabilities in the project, and if possible, get them to become patrons, president or vice-presidents.

If possible the club should secure a boat-house near the water, but this must be governed by the amount of funds available and local conditions.

The selection of a class to sail is very important in the formation of a new club. If possible, the club should take up the A-class. The reason is that these big boats are important and beautiful craft, and as such attract public attention. Moreover, they are real miniature yachts, and as such will dispel any false notions the local people may have as to "toy boats." The A-class, however, are heavy craft to carry about, and a boathouse near the waterside is an absolute necessity. The choice of a class must also be governed by the size of water available. Whatever class is selected, it should be a recognised class. This will permit the club to take part in inter-club events, compete in championships, etc. From the start members should try to go in for a class so as to permit class racing, and not get together a heterogeneous collection of all sorts with which to turn the poor Secretary's hair white as he tries to work out a suitable and equitable handicap that will please everybody.

In Britain the classes recognised by the Model Yachting Association are the International A-class, 10-Rater, International 6-metres (I.Y.R.U.), International M-class and the 36-in. Restricted Class. The I.Y.R.U. 12-metres is also recognised, but has little or no following outside Scotland.

For Racing Rules the new club cannot do better than adopt those of the Model Yachting Association, as these are based on long experience. It is also recommended that the new club becomes affiliated to the M.Y.A., as this gives it a certain status right from the start.

For the benefit of the novice a brief summary of the Model Yachting Association's Racing Rules may be given.

All racing is on the tournament system, whereby each boat meets each of her rivals in turn, the boats being sailed in pairs. Each pair

sails a heat (*i.e.*, two boards, a board being a course one way of the lake). Points are scored for each board, and the boat which has the greatest score at the end of the tournament is the winner. The scoring is 3 points for a windward board and 2 points for a running board, making a possible of 5 points per heat. When the wind gives a reaching course each way the scoring is 2 points per board, making a possible of 4 points per heat. Points are divided in a dead heat. The scoring is not changed from 3 and 2 to 2 and 2 during a round, but can be altered at the end of a round in the case of a match of several rounds.

Racing is in charge of an Officer of the Day, and it is his duty to see that the rules of sailing are not infringed, etc.

No pushing is permitted even at the start, and the boat must not be pulled forward or propelled in any way towards the winning line. If a boat comes ashore in a windward board, she must be either tacked (with or without retrimming) or put off on the same tack after having been stopped and retrimmed. When a boat is tacked the turning pole is put against the lee bow as she comes in and she may be steadied as she goes out on the new tack by a touch on the lee quarter. The hand may be used in lieu of a pole if desired. When a yacht has been tacked, her headsail must be definitely filled on the new tack before she is out of her skipper's reach. If a yacht returns to the shore she was put off from without breaking tack, she must be stopped and retrimmed.

In running or reaching boards, the yacht must be stopped and retrimmed every time she comes ashore. If a gybe is necessary it must be carried out while the yacht is stopped.

In any board a yacht after a retrim must be put off by being allowed to sail away from the hand and the pole must not be used. A yacht's way must not be accelerated when she is tacked or re-started after a retrim.

A boat must not be put off from the shore so as to involve risk of collision, and if a collision occurs through the fault of a skipper, he is disqualified for the board in question. If a foul or collision occurs accidentally, the Officer of the Day shall order a re-sail.

MODEL SAILING CRAFT

No yacht shall be withdrawn from a race unless she is disabled. Choice of berths at the start is settled by tossing unless otherwise arranged. In windward boards both competitors must start on the same tack with sails full and drawing. Position of starting marks is determined by the Officer of the Day, and they must be at least three yards apart.

The above gives a *résumé* of the most important points of the rules, but new Clubs are recommended to get a copy of the Rules from the Model Yachting Association's Publications Secretary, Mr. A. W. Littlejohn, 94 St. Dunstan's Avenue, London, W.3.

* * * *

A problem likely to present difficulty to the officials of a newly formed club is the matter of making out match cards.

By the rules of the M.Y.A., matches are sailed on the tournament system, whereby each yacht meets all the other entrants in turn. It is by no means an easy matter to make out a scheme or arrangement that fulfils this condition unless one knows the method of doing so.

Now the boats are sailed in pairs, and therefore each heat must consist of half as many pairs as there are boats. Further, as each model has to meet each of her competitors, the number of heats must be one less than the number of boats. The total number of pairs to be sailed is, therefore, the number of heats multiplied by the number of pairs in each, and as each pair have to sail a board to windward and one to leeward, the number of boards to be sailed will be twice as many again.

For instance, if there are twelve boats, there will be $12 \div 2 (= 6)$ pairs in each heat, and as each boat has eleven others to meet, there will be eleven heats. The number of pairs to be sailed will then be sixty-six, and the number of boards 132.

If there are thirteen boats, there are six pairs and one boat over in each heat. Each boat will take its "bye" in turn and will have twelve other boats to meet, so there will be thirteen heats. The total number of heats

to be sailed will then be $13 \times 6 (= 78)$ and the total number of boards $78 \times 2 (= 156)$.

For a match with fourteen boats there will be thirteen heats of seven pairs, and the total number of boards to be sailed will be 182.

It will therefore be seen that as the size of the entry increases, the amount of boards to be sailed increases very rapidly.

One problem that will come before the committee of a newly formed club is to determine how long it will take to sail a race with any given number of entries. There are two things that govern this—the first being the time that it takes to sail the length of the lake to windward and run back, and the second being the number of pairs that can be permitted on the water at the same time. For the sake of example, suppose that in moderate weather it takes six minutes to beat from the leeward end of the lake to the windward end and three minutes to run back. Then the length of a windward heat will be at the time it takes to start the requisite number of pairs plus six minutes, and for a leeward heat the time taken to start the pairs plus three minutes.

Now the number of pairs that can be permitted on the water at once will be governed by the number of officials that are available to keep track of the boats and their skippers, coupled with the fact that sufficient space must be allowed so that the later pairs do not overtake and get mixed up with those ahead of them.

For an important race beside the officer of the day and his assistant, two starters at each end are required, and these act as judges and scorers when the boats are coming the other way. Besides these, two or three umpires are required on each side of the lake, the number depending on the number of pairs on the water and the size of the lake. Even an experienced official cannot be relied on to watch more than one pair at the same time, and therefore the number of pairs on the water at the same time must not be more than two or three.

In laying down this axiom it must be understood that the authors are only dealing with important races. In a scratch club race every-

MAKING OUT MATCH CARDS

body wants to get a sail and the officer of the day will probably do everything.

Generally speaking, however, after working out the time needed, the committee should allow a margin of about 40 per cent. to allow for paltry winds, time taken for re-sails, and other unavoidable delays. Probably if there is ample time, everything will go through quickly and easily, but it is always well to be prepared, and nothing is more unsatisfactory than an unfinished race.

Now turning to the question of starter's cards, first rule up a card for the required number of pairs and heats. In this instance a ten-boat match has been taken. Now imagine the boats are numbered from 1-10. Boat No. 1 has to meet each of the others in turn, so we can put down the first pair in each heat as 1-2, 1-3, 1-4, etc., down to 1-9 and 1-10. That leaves four other pairs in each heat to be filled in. In the first heat, as Nos. 1 and 2 are meeting each other, start at No. 3 and fill in the first boat in each of the four other pairs, Nos. 3, 4, 5, down to No. 6 in the last pair. Having reached the end of the first boats in each pair working from left to right, start at the right-hand end of the line and work backwards, filling in the second boats, Nos. 7, 8, 9, till No. 10 completes the second pair.

STARTER'S CARD FOR 10-BOAT MATCH

	1st pair.	2nd pair.	3rd pair.	4th pair.	5th pair.
1st Heat	1/2	3/10	4/9	5/8	6/7
2nd Heat	1/3	4/2	5/10	6/9	7/8
3rd Heat	1/4	5/3	6/2	7/10	8/9
4th Heat	1/5	6/4	7/3	8/2	9/10
5th Heat	1/6	7/5	8/4	9/3	10/2
6th Heat	1/7	8/6	9/5	10/4	2/3
7th Heat	1/8	9/7	10/6	2/5	3/4
8th Heat	1/9	10/8	2/7	3/6	4/5
9th Heat	1/10	2/9	3/8	4/7	5/6

In the second heat, as No. 1 is meeting No. 3, we start with No. 4 as first boat of the second heat, and fill in 5, 6, and come to 7 in the last pair. Then starting with 8 the second boats are put in until No. 10 has been inserted in the third pair. To complete the last pair we start at No. 2 again. The whole card is completed

in this way. In the example shown, the numbers in black type were inserted first, working from left to right, and those in italics from right to left, working back again.

In the case of an odd number, a bye is inserted to bring the number to the next even number.

It is equally simple to write down a card, using Registered Sail Numbers, provided these are first written down in rotation.

The term "Registered Sail Numbers" may require some explanation. All boats in clubs associated to the M.Y.A. are entered in the Register and allocated sail numbers for identification.

Boats in recognised clubs have to be measured by the methods prescribed by the M.Y.A. to ensure their complying with the class rating restrictions. New clubs are advised to get into touch with the M.Y.A., and procure copies of official Rating Rules, also instructions as to methods of measurement and instruments to be used.

* * * *

In the course of this book the reader has seen something of the history of model yachting, but it was not until the present series of international races started that the general public took much interest in the sport, and the rapid growth of organised model yachting in all countries during recent years is the direct outcome.

Designers of full-sized yachts are gradually beginning to realise the great value of models for experimental work. One of the great uses of models is to test the balance of any given design, and obviously experiments that are far too costly to carry out with real yachts can readily be made with models. Sailing models provide the vehicle for trying out new ideas, and their use enables far more rapid progress to be made than would be possible without them.

Apart from the scientific and practical value of experimental work with models to the professional designer, the model gives amateur designers a chance to prove their theories that would otherwise be lacking.

MODEL SAILING CRAFT

Of course many model yachtsmen are not interested in the scientific aspect of marine modelling, but simply race for the sport it provides. Besides the racing men, there are others who prefer the quiet pleasure of cruising, and many of these prefer schooners or ketches to racing sloops. There are also quite a few square-rig enthusiasts, whose models of ships

and barques serve to remind us of times that have passed with the disappearance of sail from our merchant fleets.

Thus we come to the end of this volume, and the authors have to tender their thanks to all readers, and express the hope that these pages have proved both interesting and instructive.

AS this book is going to press, news comes from America that a new class of model racing yachts has been inaugurated and bids fair to become very popular. This is known as the X-class and the restrictions are as follows:—

X-CLASS

Sail area shall not exceed 1,000 square inches. No fore triangle measurement is taken, only actual area, exclusive of roach. Increase of area obtained by the use of bent masts or spars shall be measured as a bow and added to total sail area measurement.

Hull is unrestricted as to L.O.A., L.W.L., beam, draught, free-board, tumble-home, scantlings and materials. Punts, prams and boats with forward transoms are prohibited. Movable ballast is prohibited, also sliding or adjustable keels, metal fin keels.

ADDENDUM

Hollow of garboards shall not be less than an arc of a circle with 1 in. radius at the mid-ship section.

Any type of rig is permitted providing batten limits are not exceeded. Alternate rigs are allowed provided total S.A. is not exceeded. Spinnakers and Genoa jibs are prohibited. There are no restrictions on height of rig, mast or jib-stay. Masts and spars may be of any type, section, material or diameter.

Battens shall divide the after leaches of sails into approximately equal parts. Four battens are allowed in mainsail—upper and lower not over 4 in. in length, intermediate ones not over 5 in. Three battens are allowed in jib, not exceeding 3 in. Headsticks shall not exceed 1 in. across base.

No headsail shall be sheeted on to the main-boom. Outriggers are prohibited. Two mainsails may not be set at the same time.

GLOSSARY OF NAUTICAL TERMS

Aback.—The position of sails when the wind is acting on the fore side of them instead of the after side.
Abaft.—Relative term implying further towards the stern of a ship.
Abeam.—In a line at right angles to the centreline of the ship.
Aboard.—On board.
About.—On the other tack.
Adrift.—Broken from moorings.
Afore.—Ahead of.
Aft.—The stern end.
After.—Pertaining to the stern, or the one nearest the stern of several.
Ahead.—In advance of.
A-lee.—To leeward.
Amidships.—Centre of ship either thwartships or in a fore-and-aft direction.
Angle of Incidence.—Angle the stem makes with the surface of the water.
Astern.—Relative term meaning behind.
Athwart-hawse.—Lying across the bow.
Athwartships.—At right angles to the keel.
Avast.—Hold fast. Hence the term "Avast heaving," meaning "Stop heaving."
Awash.—Level with the surface of the water.
A-weather.—To windward.

Ballast.—Dead weight carried to give stability to a vessel.
Bare Poles.—Having no sail set.
Barge.—Flat-bottomed vessel.
Barque (also spelt *Bark*).—A kind of square-rigged vessel. See p. 177.
Barquentine (also spelt *Barkentine*).—A kind of square-legged vessel. See p. 177.
Bawley.—Kind of fishing boat used in Thames estuary, rigged as a cutter with a long bowsprit and a boomless mainsail.
Beam.—The width of a vessel. Also a transverse support.
Bear Up.—To keep further away from the wind.
Beating.—Tacking to windward.
Bend.—A kind of knot. "To bend a sail" is to lace it in position on the spars.

Bight.—A loop in a rope.
Bilge.—The part of a vessel near the keel. The turn of the bilge is where the floors turn into the sides.
Binnacle.—Stand containing compass.
Bitts.—Strong wooden posts near the centreline of the ship to make fast the cable.
Block.—A pulley through which a rope passes. This is fitted with a wheel for the rope to pass over, known as a sheave. A single block has a place for one rope to pass, a double block takes two ropes, and so on. The sling round the block is the "strop." The expression "Two blocks" means "chock-a-block."
Blue Peter.—Blue flag with white centre hoisted when a ship is about to sail.
Boat Skids.—Beams on which the ship's lifeboats rest.
Bobstay.—Stay from bowsprit to stem.
Bollard.—Strong posts for mooring purposes.
Bolt Rope.—Rope round a sail to which the canvas is sewn.
Bonnet.—An additional piece of canvas laced along the foot of a sail.
Boom.—Spar extending the foot of a sail.
Bow.—The fore end of a vessel.
Bowline.—Rope fastened to cringles in the weather leech of a square sail to haul the leech flat when sailing on the wind.
Bowline Knot.—Kind of knot forming noose. See p. 151.
Bowser.—A piece of wood or ivory with holes used for adjusting the ropes on a model yacht.
Bowsprit.—Spar projecting ahead of vessel.
Box Off.—Pay a vessel's head off on desired tack.
Brace.—Rope used to haul the yards round on a square-rigger.
Breast Hook.—A piece of wood fitted between the inwales where they join the stem.
Brig.—A kind of square-rigged vessel. See p. 177.
Brigantine.—A kind of square-rigged vessel. See p. 177.

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Bring To.—Coming to the wind preparatory to anchoring.
Broach To.—Come to wind unintentionally. It occurs when a vessel is running with the wind on the quarter by reason of the wind overpowering the rudder, bad steering or a sea striking the quarter. This always happens suddenly and a vessel may then be left broadside to wind and sea in a very dangerous position.
Broken Backed.—When the frame of a vessel is loosened or broken in the middle so that the ends sag down.
Bulkhead.—Thwartships partition.
Bull's Eye.—King of wooden thimble, usually used as a lead for a rope.
Bulwarks.—The raised side of a vessel above the deck.
Bumkin.—Sometimes written "Bumpkin." Short spar projecting from a vessel, usually from the stern. Used in a yawl to set the mizzen.
Bunt.—A term used when furling sail to denote the slack centre of the sail. Buntlines are rigged on square sails to assist in gathering the sail.
Buoyancy.—Ability to float.
Burgee.—Triangular flag. All yacht club flags should be burgees, not rectangular flags.
By the Board.—Fallen overboard.
By the Head.—A vessel is by the head when she is deeper in the bows than she should be.
By the Stern.—A vessel is by the stern when she is deeper at the stern than she should be.
By the Wind.—Close-hauled.

Camber.—The upward curve of a deck.
Canoe.—Light boat with pointed stern.
Canoe Stern.—Pointed stern.
Cant.—Heel or lean over out of the vertical.
Cap.—Fitting at top of mast supporting the topmast. Used in square-riggers.
Capstan.—A sort of windlass used for raising anchor, etc.
Caravel.—An early type of sailing ship, dating about the fifteenth century.

Carreen.—To list over to one side.
Carlines.—Short beams between the deck beams in a fore-and-aft direction.
Carrack.—A kind of mediæval sailing ship.
Carry Away.—To break a spar or rope.
Carry On.—To proceed. To make all sail at risk in a fresh wind.
Carvel.—Term used for construction when the planks are laid edge to edge.
Cast.—To pay vessel's head off on the tack she is to sail upon.
Cat Boat.—A small sailing boat with one mast stepped near the bows, setting only one sail.
Catamaran.—Sailing canoe with an outrigger.
Cat's Paw.—Light air causing a faint ripple on the water.
Caulking.—Stopping between the planks of a vessel.
Centre Board.—Sometimes called a Centre Plate. A drop keel. This is usually found in shallow draught boats where it houses in a case.
Chain Pipe.—Pipe used to lead the chain through the deck down to the chain locker where it is stowed.
Chain Plates.—Fittings used to carry the lower end of the shrouds.
Channels.—Fittings on the side of ships (particularly square-riggers) used to get a wider spread for the bottom of the shrouds.
Check.—To ease a rope out a little. To stop progress.
Chine.—Sometimes written "Chime." The joint between the sides and floors of a barge or sharpie type vessel.
Chock.—A shaped piece of wood used as a support for a boat or a spar.
Chock-a-block.—Full up. When a tackle is hauled in until it can go no further owing to the two blocks being together, it is said to be "Two blocks" or "Chock-a-block."
Cleat.—Shaped wood or metal fitting used for belaying ropes.
Clew.—After lower corner of fore-and-aft sail. Lower corners of square sail. Clew Garnet is a rope used for hauling up the

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- clews on a lower square sail. Clewline is a rope used for hauling up clews of any square sail. Clew Earring is a lanyard used for hauling out the clew of a fore-and-aft sail.
- Clinker Built.**—Boats in which the planks overlap and are fastened to each other. The overlap is known as a "land."
- Clippers.**—Fast sailing vessels used about 1860 to 1880. They were ships or barques, and were either three- or four-masted.
- Close Hauled.**—Sailing to windward with the sails trimmed as flat as possible.
- Cloths.**—Strips of sailcloth of which sails are made.
- Club.**—Short spar at foot of sail, especially a jib.
- Coamings.**—A raised edge to an opening in the deck to keep the water out.
- Coble.**—A type of fishing boat found on the Yorkshire and Northumberland coasts.
- Companion.**—Closed-in stairway from one deck to next below.
- Composite Build.**—System of building with wood planking on metal frames.
- Con.**—To direct the steering of a vessel.
- Coracle.**—Primitive boat made of skins stretched over wicker framework.
- Cordage.**—General term for rope.
- Corvette.**—A small type of man-of-war of the Middle Ages.
- Counter.**—Overhanging part of a yacht or other vessel's stern.
- Counter Stern.**—Type of stern which has a counter.
- Course.**—The lowest square sail on any mast of a square-rigged vessel.
- Covering Board.**—Outer plank of deck.
- Crack On.**—Carry more sail than is prudent.
- Crank.**—Tender under sail, listing over easily.
- Cranse Iron.**—Metal band encircling end of bowsprit with eyes for rigging.
- Crinkle.**—The ring or eyelet in the corner of the sail through which the earring or lacing is rove.
- Cross Jack (or Cro'jack).**—The lowest yard on the mizzen of a full-rigged ship.
- Crosstrees.**—Spreaders for the topmast shrouds on a sailing vessel.
- Cutter.**—Type of fore-and-aft rigged vessel with one mast. See p. 173.
- Cutwater.**—Part of the stem that first meets the water when vessel is in motion.
- Dahabeeyah.**—Type of sailing boat found on the Nile.
- Davits.**—Small cranes used in pairs for hoisting ship's boats. The anchor davit is a single small crane used for hoisting an anchor aboard.
- Deadeye.**—A sort of round block with three holes used for the shrouds on wooden sailing ships.
- Dead Light.**—A shutter to cover an open port.
- Dead Water.**—The water in a vessel's wake close to the stern.
- Deadweight.**—Total weight of a vessel with all gear aboard.
- Dead Wood.**—Part of the keel below the keel proper on which the vessel is built, used to fill in space between lead keel and hull, and provide the necessary amount of lateral surface.
- Deck.**—A platform supported on the deck-beams.
- Deck Beams.**—Thwartships beams carrying the deck.
- Deckhead.**—Underside of deck.
- Derelict.**—A vessel abandoned at sea.
- Derrick.**—Sort of crane for hoisting cargo, etc.
- Dolphin Striker.**—Otherwise the Martingale boom, a spar below the bowsprit on a square-rigged vessel.
- Dory.**—A small boat used by the Newfoundland Banks fishermen with a flat bottom.
- Downhaul.**—Rope used to haul a sail or spar down.
- Draw.**—Sails are said to draw when they are steady and full of wind. A sail that is drawing steadily and not flapping is sometimes said to be asleep.
- Drifter.**—Kind of fishing craft that uses drift nets. The nets are shot and the vessel lies to leeward of them with her head to the wind and drifts to leeward, pulling her nets slowly along.

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- Drogue.**—A conical bag that is used as a sea anchor.
- Dromon.**—Kind of sailing vessel used in the twelfth century.
- Dumb Barge.**—Barge without sails or mechanical means of propulsion, usually towed about by a tug as required.
- Dunnage.**—Pieces of wood used for wedging casks or other cargo in position.
- Earrings.**—Lanyards used to fasten the corner of sails to the spars.
- End for End.**—To shift a partially worn rope by reversing its ends.
- Eye Bolt.**—Bolt with an eye in the end through which a hook or shackle can be made fast.
- Eyelets.**—Brass rings let into sails to take the lacings.
- Eye Splice.**—Splice forming an eye in the end of a rope.
- Fairing Up.**—This term is used in several ways. In designing it means making the curves fair and agreeing the intersections in the different plans. In bread-and-butter building it means the final shaping-up of the hull after the superfluous wood has been carved away from the layers. In rib-and-plank building it means seeing that the planking will lie true and take on all moulds, and making any necessary adjustments to permit this.
- Fairlead.**—A metal fitting through which mooring lines and warps are led.
- Fashion Piece.**—On a counter-stern boat the piece of wood at the extreme stern into which the plank ends butt is called the fashion-piece.
- Fast.**—A mooring rope. It is, however, never used without a qualification. Bow-fast means a bow mooring rope. Breast-fast means a rope or line used to keep the gangway (otherwise known as a breast or brow) to the quay. Stern-fast is a stern mooring rope.
- Fetch.**—To reach or arrive at. When close-hauled a ship is said to fetch in the sense that she can make a buoy or other objective without tacking.
- Fin.**—Form of keel.
- Fishing a Spar.**—Strengthening a spar by lashing a smaller spar firmly to it.
- Flag.**—The sailor uses the term flag only for a rectangular flag, a triangular one being a "burgee."
- Flake.**—To arrange a rope in coils so that it will run out without fouling.
- Flare.**—The overhang of a vessel's topsides forward.
- Flemish Coil.**—To coil a rope down so that each flake lies outside the previous one starting in the centre.
- Floors.**—Stout timbers fitted across the keel from bilge to bilge.
- Flush Deck.**—When the deck has no raised or sunk part and forms a continuous fair line from stem to stern.
- Flying Jib.**—On a vessel setting three jibs the outer one is the flying jib.
- Flying Light.**—When a vessel has been lightened and her proper loadline is well above water.
- Foot.**—The lower edge of any sail. To "foot it" is to travel well through the water.
- Footropes.**—In a sailing vessel, ropes were fitted under the yards for the men when handling sail.
- Footstick.**—A spar extending the lower edge of a sail, particularly a headsail.
- Foremast.**—The mast nearest the bows. In a yawl or ketch, however, this is known as the mainmast.
- Forereach.**—Shooting ahead when going about under sail, or when the boat is luffed into the wind and continues to forge ahead.
- Foresail.**—In a square-rigged vessel the lowest square sail on the foremast. On a schooner the gaff-sail set abaft the foremast. On a cutter, ketch or yawl the triangular sail set immediately in front of the mainmast, though in the ketch and yawl it is often spoken of as the staysail.
- Free.**—Sailing off the wind, not close-hauled.
- Full and Bye.**—Sailing close to the wind but keeping everything drawing full.

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Gaff.—Spar extending the head of a fore-and-aft sail.

Gaff Jaws.—The jaws of the gaff which go partly round the mast.

Gammonings.—In full-riggers, the bowsprit was kept in place by gammonings (lashings) which secured it to the stem.

Gammon Iron.—Metal fitting to hold bowsprit in place at stemhead.

Garboard Strake.—The plank next the keel into which it is rebated.

Gaskets.—Pieces of rope used to put round a furled sail and secure it to the yard.

Gig.—A light kind of ship's boat.

Go About.—To tack.

Goose Neck.—The hinge attaching the boom to the mast on a fore-and-aft sail.

Goring Cloths.—The side pieces of a square sail.

Gripe.—To carry too much weather helm.

Gunter.—Kind of lugsail. (See list of fore-and-aft rigs.)

Guy.—A rope used to steady a spar. The beating guy is described elsewhere in this volume.

Gybe.—In a fore-and-aft rig to keep the vessel so much off the wind that it comes on the lee side of the sail and causes the sail to come over.

Half-Hitch.—Kind of knot. See p. 151.

Halyard (also spelt *Haulyard*) is a rope used to haul up a sail or spar.

Handsomely.—Slowly and with care.

Hank.—Metal clip used to fasten a staysail to its stay. A hank of line is a length of line tied up neatly.

Head.—Upper edge of a four-sided sail, upper corner of a triangular one.

Head Sail.—A term applied to all sails set ahead of the mast as opposed to after-sails which applies to all sails set abaft the mast.

Heart.—Kind of solid cringle used for stays and shrouds.

Heel.—The amount of list or inclination taken by a vessel. The butt end of a spar.

Heel Plate.—Metal fitting to take the heel of the bowsprit.

Heel Rope.—The rope used to run out a bowsprit or for raising a topmast that houses.

Helm.—The tiller.

Hitch.—A kind of knot.

Hogging.—When a ship strains and the ends drop.

Hoist.—The length of the luff of a fore-and-aft sail.

Hog Piece.—When the keel proper which forms the backbone of the hull is built in two parts, the upper one into which the timbers are fastened is the hog-piece.

Holiday.—Space left bare when painting.

Hoop.—Ring round mast to which sails are attached. Also a ferrule or band used to strengthen a spar.

Horse.—Metal bar athwart the vessel for a sheet to travel on.

Hove Down.—When a vessel is careened down on her side.

Hove-to.—Remaining stationary by making one sail act against another.

Idle.—When two sheets are fitted to a sail, the one that is not working is known as "idle."

Imwale.—Also known as the shelf. Longitudinal member of the hull framing placed inside the gunwale to strengthen it and support the ends of ribs and deckbeams.

Irons.—A vessel is in irons when she is head to wind and will not pay off on either tack.

Jack.—The Union Jack.

Jack-line.—Line fitted under the boom to take the bowsies that adjust the sheets.

Jack-stay.—Instead of lacing with a lanyard round the spar, a sail in a yacht is often hooked on to a wire which is run along the spar.

Jack Yard.—A small spar used on the foot of large topsails to extend the sail beyond the end of the gaff of the lower sail.

Jenny.—A short strut on the foreside of a mast to take the pull of the head of the mainsail, also serving to keep it straight against the forward pull of headsail halliards. This strut is usually fitted near the point of

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attachment of the headsail halliards and has a stay passing over it. This stay is known as the jumper stay or jenny stay.

Jib.—The foremost headsail.

Jibboom.—The continuation of the bowsprit in a square-rigger.

Jib-club.—Footstick to a jib.

Jib-topsail.—A small triangular sail set over the headsails.

Jigger.—The after-mast of a four-master.

Joggle.—A notch to house the end of a timber or other member in the frame of a vessel.

Jumper-stay.—See *Jenny*.

Jury Mast.—A temporary mast erected in place of one carried away.

Keel.—The backbone of the vessel. The part underneath the keel proper—between this and the lead keel—is known as the dead-wood or false keel.

Kelson (or *Keelson*).—An inner keel fitted over the floors and attached to the keel.

Ketch.—Type of fore-and-aft vessel with two masts. See p. 174.

King Plank.—Centre plank of deck.

Kite.—Any light weather sail.

Knee.—Angle piece used in framing up a ship.

Knot.—Way of fastening a rope. Also used of speed. A speed of 10 knots means making 10 nautical miles per hour, but 10 knots must never be used to imply a distance of 10 miles.

Land.—The overlap of the planking in a clinker-built boat.

Lanyard.—Term for a short end of light line such as that used to make fast the lower ends of the shrouds when rigging screws are not used.

Larboard.—The old name for "Port."

Lateen Sail.—A triangular sail carried on a yard which is frequently permanently bent. The heel of the yard comes down to the deck. Lateens are used in dhows and other Eastern craft.

Lateral Resistance.—Resistance to sideways movement.

Lazy.—Used in much the same way as "idle" to imply a rope that is not working.

Leach.—The afterside of a fore-and-aft sail.

Lee.—Side farthest from wind: shelter (*i.e.*, in the lee of).

Lee-Board.—Boards are fitted to the sides of barges and other flat-bottomed boats to prevent them blowing to leeward when close hauled. Of these only the leeward one is kept down.

Leeward.—On the lee side.

Leeway.—The drift a vessel makes to leeward.

List.—A permanent heel to one side.

Lubber's Hole.—An opening in the top of a square rigger through which various ropes led. So called because a man who was afraid to use the futtock shrouds could pass through.

Lubber's Line.—A line painted on the inside of the compass bowl to denote the vessel's head.

Luff.—The forward side of a fore-and-aft sail. To luff is to bring the vessel closer to the wind.

Main Boom.—Boom at the foot of the main-sail.

Main Mast.—The forward mast of a yawl or ketch. The second mast from the bows of a schooner or square-rigged vessel. The adjective "main" is used to qualify anything belonging to the mainmast.

Mainsail.—The large sail aft of the mast of a fore-and-aft rigged vessel. The lower sail on the mainmast of a square rigger.

Marconi Rig.—The Bermuda rig with a triangular mainsail.

Marry.—To bring two ropes together that are to be hauled on at the same time.

Meet Her.—When the helm has been put over and a vessel is swinging, the helm may have to be reversed to check (or meet) her.

Midsection.—Contraction of Midships Section.

Moon Sail.—In very loftily rigged clippers, a sail carried above the royals was a sky sail and the moon sail was above that.

Mould.—Template or frame used in building a planked-up boat.

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Moulded Depth.—Height of actual hull from top of keel to underside of deck. Moulded is the thickness of a timber between its curved sides as distinct from sided, which is the distance between the flat surfaces. Thus a stem might be moulded 3 in. (*i.e.*, from fore-side to after side), and 1 in. sided (*i.e.*, from port to starboard).

Offing.—To seaward.

Offsets.—A table of offsets is a table of measurements from which the building plans of a boat could be made.

Parallel Middle Body.—Ordinary yachts have no parallel middle body, but square-rigged ships had practically speaking three parts to the hull—the entry, the parallel middle body and the delivery.

Peak.—The top corner of a fore-and-aft mainsail. To peak is to haul the sail up a little more at the peak.

Pendant.—The sailor usually pronounced this "pennant." An elongated burgee (*i.e.*, triangular flag). A flag officer's pendant is "swallow-tailed" (*i.e.*, has a double tail).

Pilot Jack.—A Union Jack with a white border used as a signal for a pilot.

Pin Rail.—Rack under bulwarks in which belaying pins are set.

Pink.—A small type of mediæval sailing vessel.

Pintle.—Hinge on which the rudder pivots. When the rudder is of the lift-off type, as in a dinghy, the pin is the gudgeon and the part with the hole the pintle.

Plank.—The boards from which the sides are made are "planks" and known collectively as planking. The joint of two planks in a carvel boat is a "seam" and the overlap in a clinker-built boat the "land."

Port.—The left side of the vessel looking forward.

Port Tack.—A vessel on the port tack has the wind on her port side and the sails out to starboard.

Pram.—A boat having a forward transom.

Prau.—A native South Seas boat.

Punt.—A flat-bottomed boat, usually having a forward transom.

Quarter Beam Length.—A measurement taken for rating A-class models and boats to the Universal Rule.

Quarter.—In the region of one corner of the taffrail.

Racking.—A kind of seizing holding two ropes together.

Raffee.—A kind of square sail set flying on the fore topmast of a schooner. Also used on early cutters and ketches. It is sometimes triangular.

Rail.—The timber fitted to the top of the bulwark stanchions. A low bulwark on a racing yacht which simply constitutes a foothold is often spoken of loosely as the rail.

Rake.—The angle of masts from the vertical.

Ratlines.—Lines fitted across the shrouds of a vessel to form ladders.

Reaching.—Sailing with the wind abeam.

Reef.—To reduce canvas by tying down part of the sail.

Reef Earring.—Line used to secure the reef cringle.

Reef Cringle.—Eye let into sail to lace down the corner when reefing.

Reeve.—To pass a rope through a block.

Render.—To slip through easily.

Ribs.—The transverse members of the framework on which a boat is planked are the ribs or timbers. Usually used of the bent members as opposed to the cut timbers. In composite vessels these members are known as "frames."

Ribband.—Strip of wood laid inside a seam to prevent leakage in the system of building known as "ribband carvel."

Risings.—Short stringers fitted in small craft for various purposes, such as supporting rowing thwarts, etc.

Roach.—Outward bow in the after leach of a sail.

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Rove (or Roove).—Copper washer slightly dished placed over a nail before clenching it.

Royal.—Sail above topgallants on a square-rigger.

Rubbing Strake.—A strip of wood round a vessel's side to take chafe when along-side.

Runners.—Stays further aft than the shrouds, which are eased off on the lee side to be out of the way of the sail.

Running.—Sailing with the wind aft.

Sag.—Drop to leeward.

Sagged.—The opposite of hogged. When the ends of the vessel have maintained their level but the centre part has dropped.

Sampan.—Chinese boat.

Scarph.—Join two pieces of wood together in overlapping wedge fashion.

Scend.—To pitch into the trough of the sea.

Schooner.—A kind of two-masted fore-and-aft rigged vessel. See pp. 174, 175, 177.

Scud.—To run before a gale of wind.

Seizing.—Method of binding two ropes together.

Sharpie.—A boat with a chine.

Sheave.—The wheel in a block.

Sheer.—The rise of a ship's deck at bow and stern above the midship portion.

Sheet.—Rope controlling the trim of a sail.

Shiver.—To luff up so as to make the sails shake.

Shroud.—Stay supporting mast in a thwartships direction.

Snug.—Under safe sail.

Soldier's Wind.—A fair wind both ways.

Spider Band.—Metal fitting round mast carrying belaying pins and socket for gooseneck.

Spinnaker.—A triangular additional sail hoisted on opposite side to the mainsail when a yacht is before the wind.

Splice.—A joint between two pieces of rope.

Spoon Bow.—The modern type of overhanging yacht bow as opposed to the clipper (or fiddle) bow or the straight stem.

Starboard.—Right-hand side of vessel looking forward.

Starboard Tack.—A vessel is on the starboard tack when she has the wind to starboard and the sails out to port. This applies when close-hauled. When reaching or running she is said to be reaching or running with the wind on the starboard side.

Start a Rope.—To commence easing it.

Stay.—Rope supporting a mast in fore-and-aft direction.

Staysail.—Sail set hanked on to a stay.

Stem.—The upright part of the forward framework of the vessel.

Stern.—The after part of the vessel.

Sternpost.—The upright member forming the after part of the vessel's framing.

Stern Walk.—Gallery round the after end of naval ships up to the pre-"Dreadnought" period.

Stiff.—Not easily heeled.

Stove in.—Broken in.

Stringer.—Longitudinal member of vessel's framing.

Strop.—Loop of rope or metal round a spar.

Surge.—To render a rope quickly.

Swifter.—A single shroud in a square rigger is a swifter, and the shrouds are often spoken of collectively as the swifterns.

Tabernacle.—When a hinged mast is used (as on barges) the trunk in which it swings is known as the tabernacle.

Tabling.—Strengthening pieces of canvas at the corners of sails and where the roping is put on.

Tack.—The fore lower corner of a fore-and-aft sail.

Tacking.—Sailing to windward in zigzags. The act of going about from one tack to the other.

Taffrail.—Top part of the bulwarks going across the stern.

Taut.—Stretched.

Thimble.—Ring put into a splice.

Thole-Pins.—Wooden pins used in place of rowlocks.

Tight.—Impervious to water.

Tiller.—Bar fixed to top of rudder to steer with.

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Timbers.—The transverse members of the vessel's framing used especially when sawn or cut to shape instead of being bent.

Top Hamper.—Weight carried on deck or aloft.

Top Mast.—Upper Mast.

Top Sail.—The sail above the lower sail on any mast.

Trawler.—A sail or mechanically propelled fishing vessel that tows her nets. A drifter, on the other hand, lies head on to her nets and drifts.

Unship.—To remove.

Vane.—A fly to show the direction of the wind.

Vang.—A rope to control the end of a gaff.

Veer.—The wind veers when it shifts round clockwise. It backs when it shifts anti-clockwise. This only applies in the Northern Hemisphere, south of the line the reverse is the case. To veer cable is to pay out.

Waist.—The midship part of the upper deck.

Wake.—The track left by a vessel passing through the water.

Warp.—A rope for hauling a vessel into position.

NOTE.—*This Glossary must not be considered as a complete Dictionary of all Nautical Terms, but merely as a list of a few of the words and expressions most commonly used.*

Waterborne.—Afloat.

Waterlogged.—A vessel full of water but still afloat.

Weather.—The side from which the wind is blowing. Thus to get the weather gauge is to work to windward of.

Weigh.—Lift the anchor off the ground.

Whipping.—Binding the end of a rope to prevent it fraying out.

Wind Rode.—Riding head to wind when anchored.

Wind's Eye.—The point from which the wind blows.

Winding.—Used of twist in a hull caused by wood warping.

Wing-and-Wing.—Running dead before the wind with the mainsail on one side and the foresail on the other.

Yacht.—Vessel used for pleasure.

Yard.—Spar used to extend the upper edge of a square sail. The spar at the head of any lug sail is likewise called a yard and not a gaff.

Yaw.—When a ship does not steer a steady course and her head swings about she is said to yaw.

Yawl.—A kind of two-masted fore-and-aft vessel. See p. 173.

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